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The Use of the KWDL Technique in Developing Grade 4 Elementary School Student Combined Operations

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Abstract

The ability to recognize one's learning processes is important for learning mathematics as it helps learners to practice the thinking process of how each element works in solving mathematics problems. The K-W-D-L technique has emerged as a technique that could bring about metacognition in learning and it could be beneficial in elementary school mathematics education. The objective of the study was to examine the effectiveness of the K-W-D-L technique on the learning achievement of fourth-grade elementary school students in combined operations. The participants grade 4 students in a public school in the Thai educational context. They were cluster sampling methods. The instruments were a K-W-D-L learning management plan, a learning achievement test, and a mathematic problem-solving test. The statistics used in data analysis were percentage, mean score, standard deviation, one sample t-test, and effectiveness index. The results of the study indicate the effectiveness index of the learning management plan designed using the K-W-D-L technique reached the determining criteria. Moreover, both participants' learning achievement and mathematic problem-solving abilities were found to be at the desired level of the class.

Keywords: KWDL, elementary school, student, achievement, mathematic problem-solving

1. Introduction

As the ability to use multiple mathematical operations, such as addition, subtraction, multiplication, and division, in a single problem or equation, combined operations are important for elementary school students as they provide a foundation for more complex mathematical concepts in the future (Berlinski, 2012). The term is used to describe a type of mathematical problem that requires the application of multiple operations to find the solution. By developing the knowledge of combined operation problems, students can perform basic arithmetic operations such as addition, subtraction, multiplication, and division, use the order of operations (PEMDAS) correctly, perform arithmetic operations quickly and accurately, and have the potential to learn future mathematics courses such as algebra and geometry (Sullivan, 2006). The concept, therefore, is included in fundamental mathematics curricula across the globe (Rhodes, et al., 2020).

Basically, the principles for carrying out combined operations are to complete any calculations inside parentheses first, carry out multiplication and division starting from the left, and then perform additions and subtractions (Berlinski, 2012). However, from the perspective of a primary school student, the concept appears to be complex because they must grasp basic mathematical operations as well as the principles of combined operations. As a result, students who struggle with remembering the order of operations, working subtraction with addition, division with multiplication, and utilizing parentheses, brackets, or braces to group terms may fail to understand the concept and struggle to learn mathematics in the long run (Karagiannakis et al., 2014; Rameli & Kosnin, 2016).

In the context of the current study, teaching primary children combined operations is problematic in Thai education. In general, the state of mathematics education in Thailand is precarious. Small schools in remote locations lack financial support from the government and students' parents due to socioeconomic disparities. According to reports (e.g., Inkeeree et al., 2016; Saethow, 2019; Suwannatrai & Thongmoon, 2020), students in the area have difficulties with literacy, mathematics, foreign language, etc. This is complemented by the results of a national test demonstrating that Thai pupils have routinely scored below one-third of the total available marks (National Institute of Educational Testing Service, 2020) to illustrate the deficiencies in Thai mathematics

instruction.

It can be noted that students need metacognition – the awareness and understanding of one's own mental processes in learning to understand the concept of combined operations. To clarify, Metacognition helps them to think critically about the concepts and processes involved in combined operations, leading to a deeper and more meaningful understanding (Izzati & Mahmudi, 2018). In addition, by being aware of their own thinking and learning, students can identify areas of confusion or misunderstanding and take steps to address these issues. In this circumstance, the K-W-D-L techniques could be used to resolve the problems in teaching combined operations to elementary school students in the Thai context as it focuses on training students to understand their learning process and take control of it.

According to Sawatpon & Polyiem (2020), the K-W-D-L technique refers to the set of questions asked to assess the process in which learners are operating while doing tasks. Likewise, The K-W-D-L technique, as suggested by Shaw et al. (1997), was introduced to improve learners' thinking processes in solving problems in classes and daily life. It was based on the KWL technique (Ogle, 1986) and uses memory, cognition, and compensation in designing activities. The K-W-D-L technique encourages learners to connect their existing knowledge, transform it through repetition, information processing, and summarization, and apply the synthesized knowledge in solving tasks (Carr & Ogle, 1987).

Theoretically, the K-W-D-L approach has the potential to improve mathematics classrooms. From a constructivist perspective, for example, the strategy might enable students to reflect on prior knowledge and think critically about what they want to learn and what they have acquired (Raines, 2018). Furthermore, the strategy is intended to enhance active learning by encouraging students to actively participate in the learning process by reflecting on existing knowledge and connecting it to new information (Sholeh et al., 2020). Furthermore, the K-W-D-L strategy helps students to take responsibility for their own learning and to make educated decisions about what they want to learn and how to study it (De Silva, 2020).

In detail, the first stage – "what we know" involves introducing the class content with a set of questions to assess what they already know about the topic. In the second stage – what we want, students are asked to identify possible solutions to the problems using the information from the first stage. In the third stage – "what we did", students use the selected solution to solve mathematical problems. Finally, in the fourth stage – "what we learned", students summarize the entire process and provide answers to the questions. Therefore, students are trained to take control of their learning through an active learning atmosphere. The technique seems to have the potential in developing both mathematics knowledge and thinking skills.

In addition, previous studies have demonstrated the efficacy of the K-W-D-L technique in mathematics education. The technique has been shown to enhance students' understanding of mathematical concepts like quartet shapes (Aseeri, 2020), functions (Phromphithak, 2015), and probabilities and statistics (Al Tamimi, 2017) and mathematics skills such as mathematical problem-solving ability (Sawatpon & Polyiem, 2022; Usta & Yilmas, 2020) and metacognition skills (Tok, 2013). It could be noted from the results of the previous studies that the effectiveness of the K-W-D-L technique and KWL technique in specific areas of mathematics education, such as quartet shapes, functions, probabilities, and statistics have been found. Meanwhile, scholars still encourage more research to determine its generalizability across a wider range of mathematical topics. In addition, most of the previous studies collected data from secondary school students; employing the technique with elementary school pupils, who have distinct learning styles due to their ages and learning experiences, could provide a broader picture of its usefulness.

Consequently, the present study utilized the K-W-D-L technique as a key principle in the design of a learning management plan and applied it to fourth-grade students in an elementary school to enhance their achievement in learning combined operations. The objective of the study was to examine the effectiveness of the K-W-D-L technique on the learning achievement of fourth-grade elementary school students in combined operations.

2. Methods

The study was designed in one-group experiment research. The objective of the study was completed by considering the participants' learning achievements during and after the implementation of the K-W-D-L technique to teach the mathematics concept of combined operations. Moreover, participants' knowledge of the concept and their mathematic problem-solving abilities compared with the criteria were also taken into consideration. The detail of the data collection can be seen below.

2.1 Participants

The participants were 41 grade 4 students in a public school in the Thai educational context. They were cluster

sampling methods from 336 populations. For the background of the samples, the school is in a suburban area of a developing country in Southeast Asia. The participants had different family backgrounds of government officers, SME private business owners, and farmers whose relatives worked in big cities. Therefore, some students gained access to extracurricular activities such as after-school tutoring while some did not. The participants were informed about the project and consented to participate in it. They were treated considering ethical issues in human research during the study.

2.2 Instruments

2.2.1 K-W-D-L Learning Management Plan

The K-W-D-L technique was employed as the main principle in designing learning activities in each class. The principles of combined operations were directly instructed through lecturing and exemplification. In practice sessions, students learned to perform them through the processes of The K-W-D-L technique. The detail of class activities can be seen below.

Table 1. The K-W-D-L technique learning activities

Stages	Activities
What we know	Students were asked to examine the elements of the mathematics problems. They studied numbers and operations in the problems and recalled the principle of performing combined operations.
What we want	Students present the solutions to the problem. They illustrated their plans to solve it while the teacher facilitated their learning by giving feedback.
What we did	Students used their plan to perform combined operations on mathematics problems.
What we learned	Students presented their answers and summarize their learning.

The learning management plan takes 10 class hours and consists of 10 lesson plans. It was evaluated by scholars in mathematics education and professional teachers to be appropriate and applicable ($\bar{x}$ =4.95, S.D= 0.57).

2.2.2 Combined Operation Test

The test consists of 15 multiple-choice test items regarding combined operation. The content validity of the item was evaluated using the Index of Item Objective Congruence (IOC). All items were evaluated by 3 raters at 1.00.

2.2.3 Mathematics Problem-solving Test

The mathematics problem-solving test is a written solution test with 5 items resulting in 40 maximum points. The content validity of each item was 1.00 tested by the Index of Item Objective Congruence (IOC).

2.3 Gathering and Analysing Data

The participants took part in the learning management plan. Their performances in each lesson plan were recorded and used to identify the process effectiveness (E_1) of the learning management plan. The participants were asked to take a learning achievement test and a written solution test. The former was used to identify the product effectiveness (E_2) of the plan and participants' learning achievement of combined operations. Meanwhile, the latter was used to examine the ability to calculate combined operations. The statistics used in data analysis were percentage, mean score, standard deviation, one sample t-test, and effectiveness index. In detail, the effectiveness index (Sikkhabandit, 1984) is calculated by considering the percentage of students' average scores in exercises and the learning achievement test. The determining criteria were 75/75. The criteria for one sample t-test for both learning achievement and mathematics problem-solving ability tests was 75.

3. Results

3.1 The Effectiveness of the Learning Management Plan

The effectiveness of the learning management plan was assessed by calculating the effectiveness index (Sikkhabandit, 1984). In detail, the students' performances during learning with learning management and after learning management were compared to the determining criteria of 75/75. The results of the study are shown below.

Table 2. The effectiveness index of the K-W-D-L learning management plan

Effectiveness	n	Full Marks	$\bar{x}$	S.D.	Percentage
Process (E_1)	41	160	134.88	6.49	84.30
Product (E_2)	41	15	12.07	1.15	80.49
Effectiveness index (E_1/E_2) = 84.30/80.49					

The results show that the participant's average score during learning was 134.88 (S.D. = 6.49) out of the full mark of 160 which account for 84.30 %. In addition, the participants' average score on the learning achievement test was 80.49 % compared to the maximum point of 15 ($\bar{x}$ = 12.07, S.D. = 1.15). Therefore, the effectiveness index of the learning management plan (E_1/E_2) was 84.30/80.49 reaching the determining criteria of 75/75.

3.2 Participants' Learning Achievement and Mathematic Problem-solving Ability on Combined Operations

The effects of the K-W-D-L techniques were also assessed by examining students' knowledge and ability in solving combined operation problems. The criteria of 75 were used to determine both qualifications. The results of the study are as follows.

Table 3. The participant's learning achievement compared to the criterion

n	Full marks	Criteria (75%)	$\bar{x}$	S.D.	t	df	Sig.
41	15	11.25	12.07	1.15	4.59*	40	.000

* $p < .05$

The result of the study indicates that the participants' learning achievement of combined operations reached the determining criterion. A one-sample t-test indicates that there is a significant difference between the participant's average score ($\bar{x}$ = 12.07, S.D = 1.15) and the determining criterion (11.25), t = 4.59, p=0.00. Therefore, students could develop their knowledge regarding combined operations at the expected outcomes of the class.

Table 4. The participant's mathematics problem-solving ability compared to the criterion

n	Full marks	Criteria (75%)	$\bar{x}$	S.D.	t	df	Sig.
41	40	30	31.32	3.34	2.52*	40	.008

* $p < .05$

The findings of the study suggest that the participants have effectively achieved the target level of proficiency in solving mathematics problems involving combined operations. A statistical analysis using a one-sample t-test shows a significant difference between the average score of the participants ($\bar{x}$ = 31.32, S.D = 3.34) and the set criterion (30), with t = 2.52 and p=0.008. As a result, it can be concluded that the students have effectively improved their ability to perform combined operations, meeting the desired outcomes for the class.

4. Discussion

The results of the study could therefore be interpreted as evidence that the learning management plan benefited students learning combined operations both during and after the plan's completion. Moreover, the participants can develop their knowledge and show their ability to calculate combined operations to reach desirable outcomes of the class. Consequently, it could be claimed that the K-W-D-L technique was beneficial in mathematics education in the context presented in the current study.

The results of the study were consistent with those who also found the benefits of the techniques in mathematics education (e.g., Al Tamimi, 2017; Aseeri, 2020; Phromphithak, 2015; Sawatpon & Polyiem, 2022; Tok, 2013; Usta & Yilmas, 2020). Apart from quartet shapes (Aseeri, 2020), functions (Phromphithak, 2015), and probabilities and statistics (Al Tamimi, 2017, the result adds a piece of evidence to support the K-W-D-L technique in teaching combined operations to elementary school students. Moreover, it also joins studies that found the benefits of the technique in developing elements of mathematics learning such as mathematical problem-solving ability (Sawatpon & Polyiem, 2022; Usta & Yilmas, 2020) and metacognition skills (Tok, 2013).

This could be explained by how the K-W-D-L technique promoted active and meaningful learning in the context. During the data collection, students were encouraged to be involved in the learning process and to take responsibility for their learning. By starting with what they know and want to know, students were able to

identify their own learning needs and set goals for themselves. This process helps students to become more engaged and motivated in their learning, which can lead to improved performance and increased knowledge retention (Shaw et al., 1997). In addition, the technique allows students to reflect on their learning and identify areas where they need to improve, which can help them to develop a deeper understanding of the material. The K-W-D-L technique is, therefore, well suited to the needs of grade 4 students because it provides structure and guidance while also allowing for flexibility and creativity which are presented by the result of the study.

However, it is important to acknowledge that the effectiveness of the K-W-D-L technique in this study can be influenced by several factors, including the ability of the students, the facilitating techniques used, and the class environment. The K-W-D-L technique is designed to promote active and self-directed learning through teacher guidance, and its success is dependent on proper implementation (De Silva, 2020). Additionally, it should be noted that the technique may not be suitable for all populations. For instance, students with learning disabilities or limited prior knowledge in the subject area may struggle with the active and self-directed learning approach. Furthermore, student motivation and engagement are critical factors in the effectiveness of the K-W-D-L technique (Sawatpon & Polyiem, 2022). If students are not motivated or engaged in the learning process, the technique may not be as effective.

5. Conclusion

In conclusion, this study aimed to investigate the impact of the K-W-D-L technique on the learning achievement of fourth-grade elementary school students in combined operations. 46 students from a public school in Thailand were the subjects of the study. The results of the study showed that the K-W-D-L learning management plan was effective, as indicated by the effectiveness index, which met the determining criteria. Additionally, the study found that both the participants' learning achievement and mathematic problem-solving abilities were at the desired level of the class. These results suggest that the K-W-D-L technique can be an effective tool for promoting learning achievement in mathematics education at the elementary level.

Therefore, the study contributes to the area as it highlights the potential of the K-W-D-L technique as a tool for improving elementary students learning of fundamental concepts of mathematics like combined operations. The findings of this study could inform future research on the application of the K-W-D-L technique in other educational contexts and subject areas. Furthermore, the results of this study could be used by educators and educational policymakers to make informed decisions about the use of the K-W-D-L technique in mathematics education.

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