Enhancing Measurement Sense in Elementary Students: The Impact of 5E-Supported Interactive Digital Worksheets

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Abstract: This study investigates the effect of 5E-supported interactive digital worksheets on the development of measurement sense in 4th grade students. The research involved 52 students divided into experimental and control groups, each consisting of 26 students. The experimental group received 21 hours of instruction using interactive digital worksheets, while the control group received traditional instruction. Data were collected using the "Measurement Sense Test" developed by the researchers and analyzed with SPSS 26.0. The findings indicate that students in the experimental group, taught with 5E-supported interactive digital worksheets, had significantly higher measurement sense scores compared to the control group taught with traditional methods. Both groups showed significant improvements in pre-test and post-test scores, but the experimental group's improvement was more pronounced. These results demonstrate the effectiveness of 5E-supported interactive digital worksheets in enhancing students' measurement sense skills. The study underscores the importance of digital tools and constructivist learning models in teaching mathematical skills at the elementary level. It suggests that educators and policymakers should integrate interactive and innovative teaching tools into educational programs to improve learning outcomes. The study highlights the potential benefits of using interactive digital worksheets in mathematics education, providing evidence that such tools can significantly enhance essential skills in students.

Keywords: Digital worksheet, Measurement sense, 5E, Wizer.me

1. Introduction

In today's rapidly evolving educational landscape, the integration of technology into the classroom has become increasingly vital for enhancing student learning outcomes. The current mathematics curriculum in Turkey, aligned with international standards, emphasizes the importance of students' ability to understand and apply mathematical concepts in everyday life (Ministry of National Education [MoNE], 2018; Common Core State Standards [CCSS], 2010; National Council of Teachers of Mathematics [NCTM], 2000). Among these essential skills is the development of estimation and measurement sense, which play a critical role in fostering students' mathematical reasoning and problem-solving abilities.

Measurement sense, a subset of number sense, is the capacity to make reasonable estimations about the attributes of objects, such as length, weight, volume, and area, without relying on precise measurement tools (Micklo, 1999; Hogan & Brezinski, 2003). This skill not only supports students in making quick and logical assessments in various real-life situations but also enhances their overall mathematical comprehension and cognitive development (Kar & Öçal, 2021; Baykul, 2021). Despite its importance, research indicates that primary school students often exhibit low performance in number sense and measurement skills (Can, 2019; Cekirdekci et al., 2016; Jordan et al., 2010).

The 5E instructional model, a constructivist approach developed by Bybee et al. (2006), offers a structured framework for teaching that enhances students' engagement and understanding through five phases: Engage, Explore, Explain, Elaborate, and Evaluate. This model has been shown to improve academic achievement and motivation, making learning experiences more meaningful and enduring (Aydın Çolak, 2019; Bilgin et al., 2013).

In parallel with these pedagogical advancements, the advent of Web 2.0 tools has transformed traditional educational resources into interactive digital formats. Interactive digital worksheets, accessible via various devices, provide a dynamic and engaging learning environment that combines text, animations, and multimedia to support and enhance student learning (Khikmiyah, 2021; Zahroh & Yuliani, 2021). These tools offer immediate feedback and interactive elements that can make abstract mathematical concepts more tangible and understandable (Fahlberg-Stojanovska & Stojanovski, 2009).

This study aims to investigate the impact of 5E-supported interactive digital worksheets on the development of measurement sense in 4th-grade students. By comparing the effectiveness of these innovative worksheets with traditional teaching methods, this research seeks to provide evidence for the integration of digital tools in mathematics education to improve students' measurement skills and overall academic performance.

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1.1. Measurement Sense

Acquisition of estimation skills is beneficial in the acquisition of many measurement subjects such as length, weight, volume and area in the measurement learning domain (Hogan & Brezinski, 2003). Acquiring estimation skills provides many benefits to students. By estimating without using a measurement tool, students will be able to directly compare the property and scale to be measured. It can also positively affect the development of students' reasoning and logical thinking skills (Kar & Ocal, 2021). In addition, making predictions is a fun activity for students, and students can create a fun competitive environment in mathematics class by making predictions and comparing the results of their predictions with their friends (Baykul, 2021).

Measurement sense, a skill that can be included under number sense, can be considered as the ability to make sense of the quality of an object by using references without the need for any measurement tool. Number sense, in its most comprehensive definition, is the ability to develop useful and flexible methods (mental calculation or estimation) that individuals use to solve problems involving numbers in their daily lives and their thoughts about numbers and operations (Mcintosh et al., 1992; B. J. Reys, 1994; R. E. Reys & Yang, 1998; Sengul & Gulbagci Dede, 2014; D. C. Yang, 2005). Providing students with the ability to make predictions in primary school years can play an important role in students' number sense development. The results of the studies examining the number sense performance of students in the literature show that the number sense performance of primary school students is low (Can, 2019; Cekirdekci et al., 2016, 2020; Jordan et al., 2010; Mohamed & Johnny, 2010; Torbeyns & Verschaffel, 2016; D. C. Yang & Li, 2008).

Gaining students' sense of measurement skills has an important place in mathematics education because it can help students overcome the life problems they encounter in their daily lives through estimation without the need for paper, pencil or any measurement tool, offer practical solutions and contribute to the development of reasoning skills (Bayram, 2013; Gulbagci Dede & Sengul, 2016; McIntosh et al., 1997).

Measurement is one of the most important learning areas of mathematics and has an important place in people's lives (Van de Walle et al., 2019). Measurement is performed to calculate the lengths of objects, their weights, or the perimeter or area of a region. In addition to measuring the qualities of objects, we use measurement in many situations in daily life, such as calculating the remaining distance, calculating when the alarm will sound, and calculating the change in grocery shopping. Since measurement is a subject that people use very frequently in their daily lives and since they do not always have a suitable measuring tool with them in order to carry out the measurement process in their daily lives, the sense of measurement skill is an important skill that needs to be acquired.

1.2. 5E Learning Model and Digitization

The 5E learning model, which was developed by Rodger Bybee, adopted by the contemporary education approach and is the most widely used among the constructivist approach models in the learning process, is a learning model consisting of "enter, exploration, explanation, elaboration and evaluation" stages and aims to combine students' existing knowledge with the new concepts they encounter (Ekici, 2007). Studies in the literature show that using the 5E learning model in the learning process contributes to students' academic achievement, increases their motivation to learn and makes the knowledge they have learned more permanent (Aydin Colak, 2019; Biyikli & Yagci, 2014; Bilgin et al., 2013; Coskun, 2011; Pirci, 2018; Yilmaz, 2018).

There is a rapid change and development within the framework of the education technology concept that we have started to hear frequently due to the widespread use of technology that develops day by day. One of these developments is the digitization of traditional worksheets with Web 2.0 tools and making them interactive. Interactive digital worksheets that can be included in the education process can be used as an innovative tool in solving problems encountered in the learning environment (Rachman et al., 2017; Ramlavati et al., 2014). Interactive digital worksheets, which students can easily access with tools such as phones, tablets or computers, can provide students with a pleasant learning environment with interactive and effective media tools such as pictures, animations, text and videos (Khikmiyah, 2021; Zahroh & Yuliani, 2021).

In order to make an accurate measurement, an appropriate measurement tool must be used. However, since we cannot always have a measuring tool with us in our daily lives, it is possible to perform our measurement processes by estimation. In order to estimate the closest measurement to the result in a measurement process, it is necessary to have a developed sense of measurement skill. When the studies in the literature are examined, a limited number of studies (Eren, 2015; Kurt, 2015; Var & Altun, 2021) were found in the field of measurement learning at the primary school level, while no study measuring the sense of measurement skills of primary school students was found. In addition to studies on the field of measurement learning, there are studies on the use of Web 2.0 tools that have started to take place in the education process (Azid et al., 2020; Bedeloglu, 2016; Cirak, 2021; Dankal, 2017; Genc et al., 2021; Ozdener, 2018; Sercanoglu et al., 2021; Tas, 2016; Turel & Ozer Sanal, 2018). However, when the studies in the literature are examined, there is no study on interactive digital worksheets for students' sense of measurement skills. In this study, in which the effect of the 5E-supported

interactive digital worksheet used as a teaching tool on the development of the sense of measurement in the sub-learning area of length measurement belonging to the 4th grade measurement learning area was investigated, answers to the following research questions were aimed.

1. Do 4th grade students' sense of measurement differ significantly according to the variable of receiving measurement instruction using 5E-supported digital worksheet?

2. Is the measurement instruction using 5E-supported digital worksheet applied to 4th grade students effective on their sense of measurement?

2. Methods and Materials

2.1. Research Design

This study, which examines the development of 4th grade students' sense of measurement skills by using interactive digital worksheets prepared with the support of the 5E model, was conducted using quantitative research methods. Quantitative research method is a research method based on establishing a cause-and-effect relationship between phenomena by making descriptions and explanations in line with the numerical data obtained. The basis of this method is testing the attitudes and behaviors of individuals based on scales, observations or experiments and explaining the results with numerical data (Tutar & Erdem, 2020). In this study, the quasi-experimental design model, which is among quantitative research methods, was used. Quasi-experimental studies are a research design that aims to reveal a cause-and-effect relationship between variables by examining an existing event, phenomenon, person, object or situation and is used to compare the results (Ekiz, 2020).

In this study, which included two different groups, an experimental group and a control group, the "Sense of Measurement Test (SMT)" developed by the researcher through Plickers, a Web 2.0 tool, was applied to both groups as a pretest to measure students' "sense of measurement skills" before the process. After the process, the same test was applied to both groups as a posttest through the same application in order to monitor the students' performances. The experimental design of the study is summarized in Table 1.

Table 1. Research Design

Group	***Pre Test***	**Process**	***Pos Test***
Experimental Group	Sense of Measurement Test	Digital Worksheets	Sense of Measurement Test
Control Group	Sense of Measurement Test	Traditional Teaching	Sense of Measurement Test

The study included an experimental group and a control group. Both groups took the Sense of Measurement Test as a pre-test. The experimental group then participated in activities involving digital worksheets, while the control group received traditional teaching methods. Following the intervention, both groups took the Sense of Measurement Test again as a post-test.

2.1 Sampling Issues

The study group included in the research consisted of fourth-grade students from a state primary school affiliated with the Ministry of National Education in the Beyşehir district of Konya province during the 2022-2023 academic year. The participants in the study consisted of a total of 52 students, with 26 students in the experimental group in class 4-A and 26 students in the control group in class 4-B. Of the experimental group students, 16 were boy and 10 were girl; of the control group students, 14 were boy and 12 were girl. As this was designed as an experimental study, care was taken to ensure the equivalence of the groups. The research was conducted at the school where the researcher teaches. This facilitated the implementation of the study for the researcher.

Table 2. Distribution of Participants

Grup	**Number of Participants**
Experimental Group	26
Boy	16
Girl	10
Control Group	26
Boy	14
Girl	12

2.2. Measurement Tool

In this study, the "Sense of Measurement Test (SMT)" developed by the researcher was used as a data collection tool. With this test, it was aimed to measure the students' sense of measurement skills.

The "Sense of Measurement Test", which was developed by the researcher by examining the 4th grade mathematics textbook and in line with the acquisitions for estimation of the sub-learning areas of length measurement, perimeter measurement and area measurement in the measurement learning area within the scope of the mathematics curriculum, consists of 24 multiple-choice questions by taking the opinion of an expert in the field of mathematics education and three classroom teachers. In order to calculate the validity and reliability coefficients of this test, a pilot study was conducted with the participation of 105 fifth grade students. Since this test aims to measure students' sense of measurement skills rather than measuring students' academic achievement, it was applied through "Plickers", a Web 2.0 tool, to prevent students from using pen and paper. In addition, it was observed that the response time of the prepared test should not exceed 1 lesson hour. The data obtained from the pilot study were analyzed using SPSS 26.0 statistical program. The item analyzes related to the pilot study are given in Table 3.

Table 3. "Sense of Measurement Test" Pilot Application Item Analysis

Item	**pj**	**pj Comment**	**rjx**	**rjx Comment**
1	.39	Middle	.55	Very good
2	.45	Middle	.30	Quite good
3	.70	Very easy	.31	Quite good
4	.64	Very easy	.49	Very good
5	.23	Difficult	.16	Must be removed
6	.46	Middle	.37	Quite good
7	.54	Easy	.42	Very good
8	.62	Easy	.36	Quite good
9	.60	Easy	.48	Very good
10	.53	Easy	.31	Quite good
11	.32	Middle	.33	Quite good
12	.42	Middle	.30	Quite good
13	.44	Middle	.32	Quite good
14	.39	Middle	.40	Very good
15	.60	Easy	.45	Very good
16	.77	Very easy	.31	Quite good
17	.50	Easy	.37	Quite good
18	.46	Middle	.30	Quite good
19	.36	Middle	.25	Must be corrected
20	.69	Easy	.39	Quite good
21	.67	Easy madde	.42	Very good
22	.68	Easy madde	.43	Very good
23	.40	Middle	.21	Should be corrected
24	.28	Difficult	.29	Should be corrected
Mean	.51		.35	

When the discrimination indices of the items in Table 3 are analyzed, item 5 should be removed from the test, while items 19, 23, and 24 should be corrected. If the item discrimination index of the items of a test is calculated as ≤.19, this item should be removed from the test, if the item's item discrimination index is in the range of .20-.29, the item should be corrected and improved, an item with an item discrimination index in the range of .30-.39 is considered a very good item, and an item with a discrimination index ≥.40 is considered a very good item (Crocker & Algina, 1986).

After the necessary arrangements of the "Sense of Measurement Test" were made after the pilot application, the final application was carried out with the participation of 118 fifth grade students for the final results of the test. As in the pilot application, the test was applied with the "Plickers" tool and completed in one lesson hour. The reason for selecting fifth grade students in the pilot and final application was that it was thought that they had achieved the gains related to the measurement learning area in the previous years. The "Sense of Measurement Test" was finalized as a multiple-choice test consisting of a total of 23 questions, 1 with 2 options, 3 with 3 options and 19 with 4 options. The questions in the measurement tool consist of 10 questions on length measurement, 8 questions on environment measurement, and 5 questions on area measurement. The final item statistics and item analysis of the developed "Sense of Measurement Test" are given in Table 4 and Table 5.

Table 4. "Sense of Measurement Test" final item statistics

SMT	N	Number of Items	$\bar{X}$	ss	pj	rjx	KR-20
	118	23	12.44	4.41	0.51	0.37	0.80

In the "Sense of Measurement Test", an evaluation was made in such a way that students received "1" point for each question they answered correctly and "0" point for each question they answered incorrectly or left blank. When Table 4 was examined, it was seen that the mean difficulty of the items of the test was medium difficulty (.51), while the KR-20 internal consistency coefficient of the test was calculated as .80. When the reliability coefficient of a developed test is ≥.70, it means that the test is reliable (Buyukozturk, 2020).

Table 5. "Sense of Measurement Test" Final Application Item Analysis

Item	pj	pj Comment	rjx	rjx Comment
1	.41	Middle	.54	Quite good
2	.44	Middle	.32	Quite good
3	.66	Easy	.34	Quite good
4	.62	Very easy	.47	Very good
5	.46	Middle	.35	Quite good
6	.54	Easy	.47	Very good
7	.54	Easy	.34	Quite good
8	.57	Easy	.48	Very good
9	.55	Easy	.34	Quite good
10	.34	Middle	.33	Quite good
11	.44	Middle	.34	Quite good
12	.46	Middle	.33	Quite good
13	.37	Middle	.38	Quite good
14	.60	Easy	.45	Very good
15	.75	Very Easy	.34	Quite good
16	.51	Easy	.33	Quite good
17	.49	Middle	.38	Quite good
18	.40	Middle	.40	Very good
19	.67	Easy	.39	Quite good
20	.68	Easy	.38	Quite good
21	.66	Easy	.38	Quite good
22	.44	Middle	.39	Quite good
23	.32	Middle	.35	Quite good
Mean	.51		.37	

When Table 5 is examined, it is seen that 11 items in the "Sense of Measurement Test" are of medium difficulty, 11 items are easy and 1 item is very easy. The item difficulty index of a test takes a value in the range of 0-1. As the difficulty index of an item approaches "0", the item becomes more difficult, while the item becomes easier as it approaches "1" (Turgut & Baykul, 2019). If the item's difficulty index is ≤.29, it is considered as a difficult item, if it is between .30-.49, it is considered as a medium difficulty item, if it is between .50-.69, it is considered as an easy item, and if it is ≥.70, it is considered as a very easy item (Atilgan et al., 2019). The questions included in the measurement tool are provided in the Appendix section.

2.3. Data Collection

Before starting the implementation process, the necessary legal permissions were obtained to avoid legal problems during the process. Necessary correspondence was made with the "Konya Provincial Directorate of National Education" and permission was obtained on 25.01.2023 with the No: E-83688308-605.99-69228135 permission was obtained. In addition, the school administration and the classroom teacher of the students in the control group were informed about the process and their approval was obtained. Ethical permissions for the study were obtained by applying to "Necmettin Erbakan University Social and Human Sciences Scientific Research Ethics Committee Presidency" on 14.10.2022 with Decision No: 2022/356. A class was assigned as the experimental group and a class as the control group. Before the implementation process, both the experimental group and the control group students were administered the "Sense of Measurement Test" as a pretest using "Plickers". During the process, the students in the experimental group taught their lessons using interactive digital worksheets with the "wizer.me" Web 2.0 tool prepared by the researcher for 21 lesson hours for 4 weeks within the program prepared on the basis of the annual plan, while the students in the control group taught the same subject by the same instructor within the scope of the existing mathematics program with traditional methods. At the end of 21 class hours, the "Sense of Measurement Test", which was applied as a pretest, was applied as a posttest via "Plickers" to observe the students' sense of measurement skills. The course content covered throughout the study is presented in Table 6.

Table 6. Learning outcomes related to measuring length in the 4th grade mathematics curriculum.

Sub-learning area	Achievement Number	Achievement
Length Measurement	M.4.3.1.1.	Indicates the areas of application for the standard length measurement unit, the millimeter.
	M.4.3.1.2.	Explains the relationships between units of length measurement and writes them in terms of each other. a) Limited to binary conversions between millimeters and centimeters, centimeters and meters, and meters and kilometers. b) Conversions requiring decimal notation are not performed.
	M.4.3.1.3.	Estimate the length that can be measured directly using the most appropriate unit of measurement, and check the estimate by measuring it. Do not use kilometers.
	M.4.3.1.4.	Solves problems that require up to three operations using units of length measurement.
Environmental measurement	M.4.3.2.1.	Explains the relationship between the perimeter and side lengths of squares and rectangles. b) It is determined that the perimeter of a square is four times the length of one of its sides. c) In such activities, graph paper or dotted paper is used (by relating it to the number of units).
	M.4.3.2.2.	Create different geometric shapes with the same perimeter. Use dotted or isometric paper to complete the activities.
	M.4.3.2.2.	Solves problems related to calculating the perimeter of shapes. a) The circumference of a circle is not included. b) Work on setting up problems is also included.
Area Measurement	M.4.3.3.1.	The areas of shapes are determined by the number of unit squares covering that area. a) In addition to recognized shapes, indented shapes such as leaves and hands drawn on graph paper are also used. b) When giving examples, work is done on shapes with the same perimeter but different areas.
	M.4.3.3.2.	Relates the area of squares and rectangles to addition and multiplication operations. a) Calculates the areas of squares and rectangles by counting square units. b) Performs area calculation exercises using counting, repeated addition, and multiplication operations. c) Utilizes the row-column relationship while performing these exercises.

2.4. Implementation Process

Before starting the implementation process, the "Sense of Measurement Test" was administered to 26 students in the experiment group as a pretest via "Plickers". In the first and second weeks of the study, the students used the interactive digital worksheets prepared on wizer.me and the acquisitions related to the sub-learning area of length measurement in the current mathematics curriculum for a total of 10 lesson hours for two weeks. Examples of the digital worksheets used in the experimental group are provided in Figures 1 and 2.

Figure 1. Worksheet engage activity on measuring length

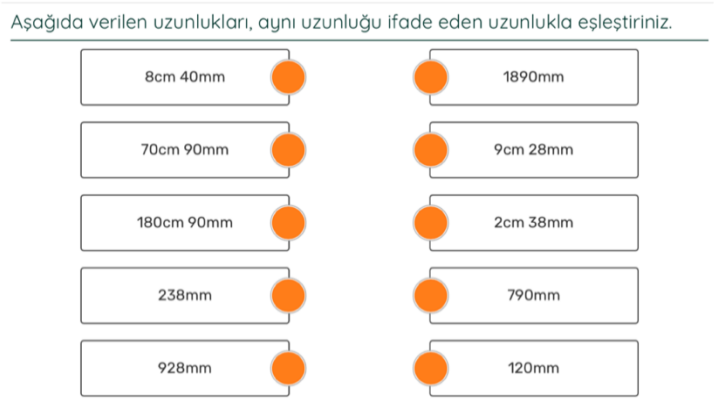

Figure 2. Worksheet length measurement elaborate activity

In Figure 1 and Figure 2, examples of the activities in the interactive digital worksheet related to the sub-learning domain of length measurement prepared through wizer.me are given. This worksheet was created on the Wizer.me platform with integrated GeoGebra material.

In the third week of the implementation process, three objectives in the current mathematics curriculum related to the 4th grade environment sub-learning area were taught for 5 lesson hours using digital worksheets prepared with 5E support and including different activities at each stage of the model via wizer.me.

An example of an element related to the topic of area is provided in Figure 3.

Figure 3. Worksheet environmental measurement elaborate activity

Figure 3 shows an example of the activities in the interactive digital worksheet on the sub-learning area of environmental measurement prepared through wizer.me integrated dot paper.

In the fourth week, which was the last week of the study, the acquisitions related to the 4th grade area measurement sub-learning area in the current curriculum were covered for 5 lesson hours. Thus, each student in the experimental group completed the application process by using the worksheets prepared through wizer.me interactively with the objectives in the sub-learning areas of length measurement, perimeter measurement and

area measurement in the 4th grade measurement learning area during 21 lesson hours for 4 weeks. An example of an element related to the topic of area is provided in Figure 4.

Figure 4. Worksheet fieal measurement elaborate activity

Figure 4 shows an example of an activity at the deepening stage in the interactive digital worksheet related to the field measurement sub-learning area prepared through wizer.me integrated different visuals.

In the context of this study, prior to the experimental implementation, the “Sense of Measurement Test” was administered to 26 fourth-grade students in the control group as a pretest using the “Plickers” application. This test was conducted to assess the students’ initial level of understanding and skills related to measurement. According to Frankel et al. (2012), in experimental studies where the instructional process is carried out by different individuals, such as the researcher or the regular classroom teacher, unintended interactions may occur within the experimental group. These unintentional interactions can result in additional learning outcomes or gains, which may compromise the internal validity of the study. To prevent such influences from affecting the internal consistency of the research, the lessons for the control group were conducted solely by the researcher throughout the intervention period. The instruction in the control group was carried out over four weeks, encompassing a total of 21 lessons. The teaching strictly adhered to the current national mathematics curriculum and utilized traditional instructional methods, without incorporating any experimental strategies or innovative interventions. Throughout this four-week period, the instructional content was organized in alignment with the scope and sequence of the curriculum. In the first and second weeks, students were taught topics related to length measurement, which included recognizing standard units, using measurement tools accurately, and comparing different lengths. During the third week, the focus shifted to perimeter measurement, where students engaged in identifying the perimeter of various geometric shapes and understanding the relationship between side lengths and total perimeter. In the fourth and final week, instruction was devoted to area measurement, aiming to develop students' conceptual understanding of area and their ability to calculate the area of regular and irregular shapes using unit squares and formulas. At the end of the four-week period, the “Sense of Measurement Test” was re-administered to the same 26 students in the control group as a posttest via the Plickers application. This allowed for a comparison between pretest and posttest results, with the purpose of evaluating any change in students' measurement-related skills that could have resulted solely from traditional instruction. The posttest data from the control group also served as a baseline for comparing with the outcomes of the experimental group, thereby supporting the validity and reliability of the study’s findings.

2.5. Data Analysis

In the study, the data obtained with the "Sense of Measurement Test" data collection tool were analyzed using the SPSS 26.0 statistical package program. Since the number of participants in the study was less than 50, "Shapiro-Wilk Test" was used in the normality analysis of the data (Buyukozturk, 2020). The results of the test applied are given in Table 7.

Table 7. Posttest normality analysis of experimental and control groups

Data Collection Tool	Group	Skewness	Kurtosis	Shapiro-Wilk		
				Statistic	df	*p*
Post-test	Experimental	-.268	-.378	.940	26	.136
	Control	-.010	-.921	.962	26	.433

When Table 7 is examined, the scores of the experimental group students ($p > .05$) and the scores of the control group students ($p > .05$) show a normal distribution. As a result of the analysis, it was seen that the skewness and kurtosis values were between "-1 and 1" for both groups. Skewness and kurtosis values between "-1 and 1" indicate that the data are normally distributed (Hair et al., 2013). Since the students' posttest scores showed normal distribution, parametric tests were used to analyze the data. In this study, "measurement teaching with 5E supported interactive digital worksheets" was determined as the independent variable and "development of sense of measurement" was determined as the dependent variable. For the first sub-problem of this study, an

independent samples t-test was conducted to see whether the difference between the mean posttest scores of the experimental group and the control group was significant. Independent groups t test is used to compare the mean scores on a specific dependent variable obtained from two different independent groups (Guclu, 2020; Taspinar, 2017). In addition, for the second sub-problem of the study, the dependent groups t test was used to compare the pretest-posttest achievement scores of the students in the groups separately. The dependent groups t test is a parametric test used to compare data collected from the same group at two different times or in two different situations (Guclu, 2020; Taspinar, 2017).

2.6. Research Ethics

This research was conducted under ethical guidelines and was approved by the Necmettin Erbakan University Social and Human Sciences Scientific Research and Publication Ethics Committee on 14 October 2022 with the decision number 2022/356.

3. Results

Before starting the study process, the pre-test scores of the students in the experimental group and the control group were analyzed using the independent samples t test to see whether their sense of measurement skills were equivalent. The independent t test results of the pretest results of the experimental and control groups are presented in Table 8.

Table 8. Descriptive statistics for the pretest scores of the students in the experimental and control groups

Groups	N	$\bar{X}$	SD	df	t	*p**
Experimental Group	26	13.346	2.243	50	2.590	0.558
Control Group	26	12.923	2.883			

When Table 8 is examined, there was no significant difference in the mean scores of the students in the experimental group and the control group from the pretest (t = 2.590; $p > .05$). When the mean scores of the students were examined, it was seen that the mean pretest score of the students in the experimental group was 13.346 and the mean pretest score of the students in the control group was 12.923. In this context, it can be said that the sense of measurement skills of the students in the two groups are equivalent to each other.

In order to answer the first sub-problem of the study, "Do the 4th grade students' sense of measurement differ significantly according to the variable of receiving measurement instruction using 5E-supported digital worksheets?", the difference between the mean scores of the students in the experimental and control groups from the "Sense of Measurement Test" applied as a posttest was analyzed. Descriptive statistics related to the analyzes are given in Table 9.

Table 9. Descriptive statistics of the posttest scores of the students in the experimental and control groups

Variable	Group	N	$\bar{X}$	SD
Post-test	Experimental Group	26	17.192	2.638

When the statistics in Table 9 are examined, it is seen that the mean score of the experimental group ($\bar{X}$ = 17.192; SD = 2.638), which conducted their lessons using 5E-supported interactive digital worksheets, was higher than the mean score of the control group ($\bar{X}$ = 15.384; SD = 2.499), which conducted their lessons using traditional methods.

Independent samples t test was used to see whether the difference between the mean scores of the groups in the posttest was statistically significant. The results of the independent samples t test are given in Table 10.

Table 10. Independent samples t test results for the posttest scores of the students in the experimental and control groups

Gropus	N	$\bar{X}$	SD	df	t	p*
Experimental Group	26	17.192	2.638	49.854	2.536	.014
Control Group	26	15.384	2.499			

According to Table 10, the difference between the mean scores of the groups in the posttest was statistically significant and this difference was in favor of the experimental group (t = 2.536; $p < .05$). As a result of the analysis, it was determined that the use of 5E-supported interactive digital worksheets had a positive effect on the development of students' sense of measurement skills.

In order to answer the second sub-problem of the study, "Is the measurement instruction using 5E-supported digital worksheets applied to 4th grade students effective on their sense of measurement?" descriptive statistics were calculated and dependent groups t-test was performed. The descriptive statistics of the results of the "Sense of Measurement Test" applied before and after the study are given in Table 11.

Table 11. Descriptive statistics of the students in the experimental and control groups regarding their SMT scores

Test	N	$\bar{X}$	SD
Experimental Group SMT Post-test	26	17.192	2.638
Expretimental Group SMT Pre-test	26	13.346	2.243
Control Group SMT Post-test	26	15.384	2.499
Control Group SMT Pre-test	26	12.923	2.883

According to Table 11, it is seen that the mean scores of the experimental group students in the posttest ($\bar{X}$=17.192; SD=2.638) are higher than the mean scores of the pretest ($\bar{X}$=13.346; SD=2.243). When the mean scores of the students in the control group are analyzed, it is seen that the mean score of the posttest ($\bar{X}$=15.384; SD=2.499) is higher than the mean score of the pretest ($\bar{X}$=12.923; SD=2.883). It is seen that the posttest mean scores of both groups are higher than the pretest mean scores. Dependent groups t-test was used to see whether the difference in mean scores was significant within the groups. Table 12 shows the results of the dependent groups t test for the experimental group.

Table 12. Dependent groups t-test for the students in the experimental group regarding their SMT scores

Test	N	$\bar{X}$	SD	df	t	*p**
SMT Post-test	26	17.192	2.638	25	14.556	.000
SMT Pre-test	26	13.346	2.243			

According to Table 12, it was seen that the difference between the pretest-posttest mean scores of the students in the experimental group was statistically significant (t = 14.556; $p < .05$) as a result of teaching the sub-learning areas of length, perimeter and area measurement in the measurement learning domain during 21 lesson hours using 5E-supported interactive digital worksheets. In this context, it can be said that 5E supported interactive digital worksheets are effective in the development of students' sense of measurement skills.

Table 13 shows the dependent groups t test result for the control group.

Table 13. Dependent groups t-test for the students in the control group regarding their SMT scores

Test	N	$\bar{X}$	SD	df	t	*p**
SMT Post-test	26	15.384	2.499	25	9.412	.000
SMT Pre-est	26	12.923	2.883			

According to Table 13, it was seen that the difference between the pretest-posttest mean scores of the students in the control group was statistically significant (t = 9.412; $p < .05$) as a result of teaching the sub-learning areas of length, perimeter and area measurement in the measurement learning domain during 21 lesson hours with traditional methods within the scope of the current mathematics curriculum. In this context, it can be said that the lessons taught with traditional methods within the scope of the current mathematics teaching program are also effective in the development of students' sense of measurement skills, but this effect is not as effective as the measurement teaching process using 5E-supported digital worksheets.

4. Discussion

In this study, which investigated the effect of 5E-supported interactive digital worksheets used in the teaching of the sub-learning areas of length, perimeter and area measurement of the 4th grade measurement learning domain on the development of sense of measurement skills, the findings were obtained as a result of the analysis of the data obtained from the "Sense of Measurement Test" developed by the researcher.

When the mean scores of the students who participated in the study from the "Sense of Measurement Test" administered as a posttest were compared, it was seen that the mean score of the students in the experimental group who taught their lessons with 5E-supported interactive digital worksheets was higher than the mean score of the students in the control group who taught their lessons with traditional methods within the scope of the current mathematics curriculum. The difference between the two groups was found to be statistically significant and this difference was in favor of the experimental group. This situation is similar to the results of many studies in the literature. It is seen in the results of the studies that the lessons taught using worksheets in the mathematics lesson teaching process contribute to academic achievement more than traditional methods (Aktepe, 2012; Aydogdu et al., 2014; Ceylan & Turnuklu, 2002; Cekmez, 2013; Erduran Ceylan, 2003; Ev, 2003; Kutluca & Baki, 2013; Ozdemir, 2012; Yagdiran, 2005; Yasa, 2010; Yilmaz et al., 2010; Zehir, 2010; Zengin, 2015). The contribution of worksheets to student achievement is not limited to mathematics, but it is also seen in the results of the studies conducted in science (Atasoy & Akdeniz, 2006; Bayrak, 2008; Besler, 2009; Bozdogan, 2007; Costu et al., 2003; Ozdemir, 2006), social studies and life science courses (Gecit et al., 2011; Kaymakci, 2010). As a result of the study, there may be many reasons for the increase in sense of measurement skills in favor of the experimental group. Students participate more actively in mathematics lessons when using interactive digital worksheets (Wei & Ismail, 2010; Zengin, 2015). In addition, interactive digital worksheets are more interactive

than traditional worksheets (Fahlberg-Stojanovska & Stojanovski, 2009; Lavicza & Papp-Varga, 2010; Yilmaz et al., 2010). Since interactive digital worksheets provide students with the opportunity to interact directly with the material, students can make the abstract concepts of mathematics concrete and increase the retention of learning (Kaymakci, 2010; Kutluca & Baki, 2013; Tatar, 2013; Zehir, 2010; Zengin, 2015). In addition, students can get instant feedback on their responses to the activities in digital worksheets and mislearning can be corrected instantly (Zengin, 2015). These features offered by interactive worksheets are thought to be effective in increasing the sense of measurement skills of the students in the experimental group. In summary, interactive digital worksheets in measurement teaching are thought to have a positive effect on the development of students' sense of measurement skills due to their features such as active participation, instant feedback, visualization supports, etc.

According to the analysis of the pretest-posttest mean scores of the experimental and control group students who participated in the study from the "Sense of Measurement Test", there is a statistically significant gain in the sense of measurement skills of both the students in the experimental group and the students in the control group. It can be said that the students' exhibiting disciplined behaviors during the study process, fulfilling the tasks given by the teacher completely and diligently, and the students in the experimental group being able to use computers and computer technologies at an adequate level and showing interest contributed to the development of students' sense of measurement skills.

5. Conclusion and Recommendation

Within the scope of this study, which examined the effect of 5E-supported interactive digital worksheets on the development of 4th grade students' sense of measurement skills, it was observed that the lessons taught using 5E-supported interactive digital worksheets improved students' sense of measurement skills more than the lessons taught with traditional methods within the scope of the current mathematics teaching program. In addition, at the end of the process, it was observed that both the students in the experimental group and the students in the control group improved their sense of measurement skills. The pretest-posttest mean scores of the students in both groups showed a significant difference in favor of the posttest. In addition to this increase, when the mean scores of the students in the experimental group were compared with the mean scores of the students in the control group, it was seen that the increase in the mean scores of the students in the experimental group was higher.

In summary, the use of 5E-supported interactive digital worksheets in measurement teaching has a positive effect on the development of students' sense of measurement skills. This situation also revealed a statistically significant difference. Educators should consider incorporating 5E-supported interactive digital worksheets into their teaching practices, especially for topics that involve measurement and estimation. These tools have been shown to enhance student engagement, understanding, and retention of mathematical concepts. Professional development programs should be provided for teachers to familiarize them with the effective use of Web 2.0 tools and interactive digital worksheets. This training can help teachers integrate these tools seamlessly into their existing curricula. Curriculum developers should incorporate interactive and digital learning resources into the mathematics curriculum to support various learning styles and improve students' measurement sense and overall mathematical skills.

Future research should explore the long-term effects of using interactive digital worksheets on students' mathematical abilities and other subject areas. Additionally, studies could investigate the impact of these tools on different age groups and educational levels. Teachers should create a balanced classroom environment where traditional teaching methods are complemented by interactive digital tools. This approach can cater to diverse learning preferences and enhance overall student performance. Schools should implement feedback mechanisms to gather data on the effectiveness of digital learning tools. This feedback can be used to make informed decisions about instructional strategies and resource allocation. By implementing these recommendations, educators and policymakers can enhance the quality of mathematics education and better prepare students prediction capabilities and sense skills.

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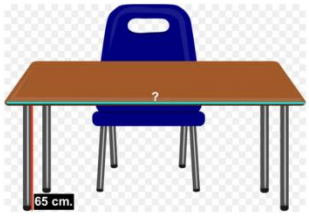
Appendix

1) Görselde verilen öğrenci sırasının yerden yüksekliği 65 cm'dir. Buna göre yeşil çizgi ile gösterilen öğrenci sırasının uzunluğu aşağıdakilerden hangisi olabilir?

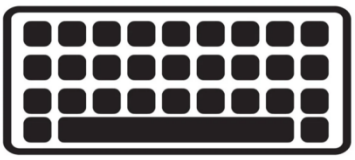


A 80cm - 100cm
B 100cm - 120cm
C 120cm - 150cm
D 150cm - 180cm

2) Görselde verilen ailede kız çocuğunun boyunun uzunluğu 130 cm olduğuna göre, babanın boyunun uzunluğu kaç cm olabilir?

A 140cm
B 160cm
C 180cm
D 200cm

3) Görseldeki klavyenin bir tuşunun uzunluğu 1 cm'dir. Buna göre bu klavyenin uzun kenarı kaç cm'dir?



A 10cm
B 20cm
C 30cm
D 40cm

4) Yandaki kare şeklinde satranç tahtasının bir kenarının uzunluğu 50 cm'dir. Buna göre satranç tahtasında yer alan küçük karelerden bir tanesinin bir kenar uzunluğu aşağıdakilerden hangisi olabilir?

A 3cm
B 6cm
C 9cm
D 12cm

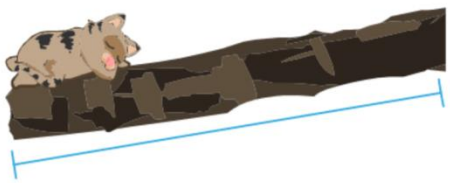
5) Muhsin, evinden Umut'un evine 40 metre yürüyor. Daha sonra okula doğru yürümeye devam ediyor.
Muhsin'in evi ile okul arasındaki uzaklık ne kadar olabilir?
(TIMSS 2015)

A 40 metre
B 80 metre
C 100 metre
D 130 metre

6) Şekildeki adam 2 m uzunluğundadır. Ağacın uzunluğunu tahmin ediniz.
(TIMSS 2007)

A 4 metre
B 6 metre
C 8 metre
D 10 metre

7) Kedinin uzunluğu 25 cm olduğuna göre ağaç dalının uzunluğunu tahmin ediniz.

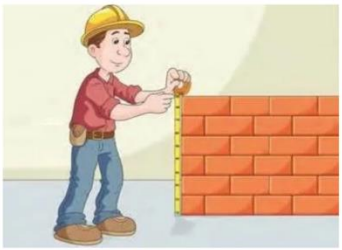


A 50 santimetre
B 75 santimetre
C 100 santimetre
D 110 santimetre

8) Trafik lambasının boyu 2 metre olduğuna göre ağacın boyunu tahmin ediniz.

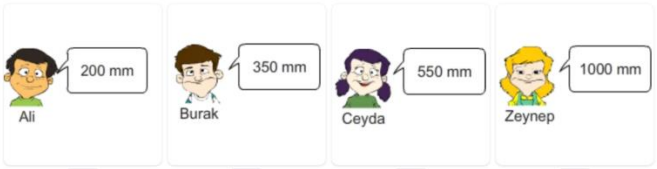
A 2 metre
B 4 metre
C 6 metre
D 8 metre

9) Yandaki duvarın yüksekliği 1 metre olduğuna göre bir tuğlanın yükseliği ne kadar olabilir?



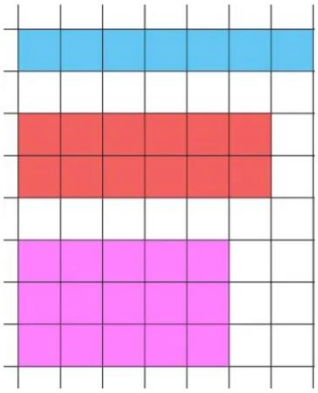
A 10 santimetre
B 15 santimetre
C 20 santimetre
D 25 santimetre

10) Ali, Burak, Ceyda ve Zeynep bir yetişkinin adımının uzunluğunu tahmin etmişlerdir. Buna göre en yakın tahmini hangi öğrenci yapmıştır?



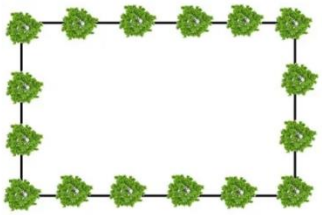
A B C D

11) Yanda verilen geometrik şekillerden hangisinin çevresi diğerlerinden daha küçüktür?



A Mavi
B Kırmızı
C Pembe
D Hepsinin çevresi eşittir

12) Görseldeki bahçenin çevresine 4 metre aralıklarla ağaç dikilmiştir. Buna göre bu bahçenin çevre uzunluğunu tahmin ediniz?

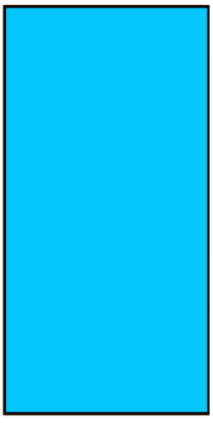


A 24 metre
B 44 metre
C 64 metre
D 84 metre

13) Görseldeki dikdörtgenin kısa kenar uzunluğu 15 santimetre olduğuna göre şeklin çevre uzunluğunu tahmin ediniz.

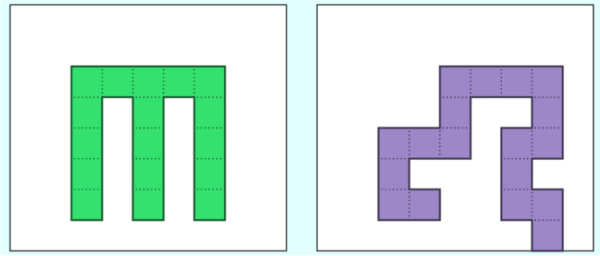
A 45
B 60
C 90
D 120

14) Yandaki dikdörtgenin uzun kenar uzunluğu 60 santimetre olduğuna göre çevresinin uzunluğunu tahmin ediniz?



A 150
B 180
C 210
D 240

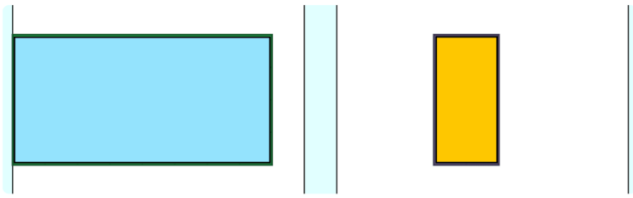
15) Aşağıdaki şekillerden hangisinin çevresi diğerine göre daha büyüktür?



A Yeşil şekil

B Mor şekil

16) Aşağıdaki mavi dikdörtgenin çevresinin uzunluğu 24 birim olduğuna göre, sarı dikdörtgenin çevre uzunluğunu tahmin ediniz.



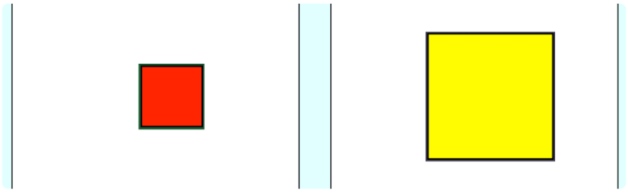
A 4

B 12

C 20

D 28

17) Aşağıdaki kırmızı karenin çevre uzunluğu 8 birim olduğuna göre sarı karenin çevre uzunluğunu tahmin ediniz.



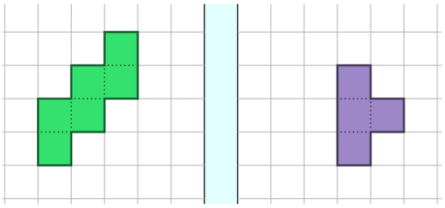
A 16

B 26

C 36

D 46

18) Aşağıdaki iki şekilde de aynı sayıda kare kullanılmıştır. Hangi şeklin çevre uzunluğu daha büyük olabilir?

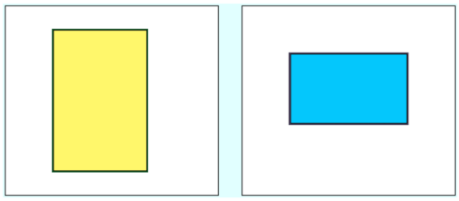


A Yeşil şekil

B Mor şekil

C Çevre uzunlukları eşittir.

19) Aşağıdaki dikdörtgenlerden hangisinin alanı daha büyüktür.

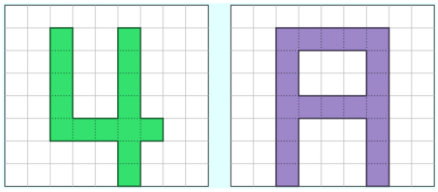


A Sarı dikdörtgen

B Mavi dikdörtgen

C İkisinin de alanları eşit.

20) Aşağıdaki şekillerden hangisinin alanı daha büyüktür?

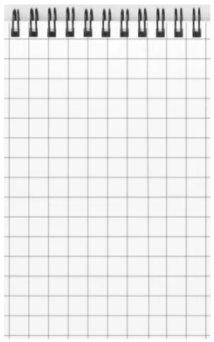


A Yeşil şekil.

B Mor şekil.

C İki şeklin alanı eşittir.

21) Görseldeki not defterinin alanı kaç birim kare olabilir?



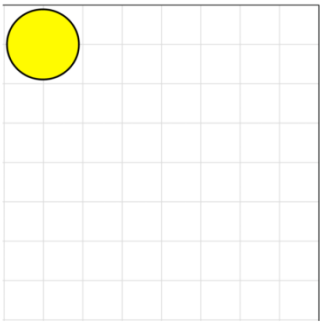
A 100 birim kare

B 150 birim kare

C 200 birim kare

D 250 birim kare

22) Yandaki kareli kağıtta verilen taralı bölgenin alanı 4 cm kare olduğuna göre tüm kareli kağıdın alanını tahmin ediniz.



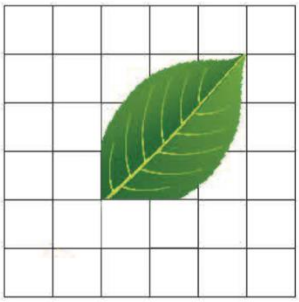
A 68

B 136

C 204

D 272

23) Görseldeki kareli kağıtta üzerindeki yaprağın kapladığı alanı tahmin ediniz?



A **2 birim kare**
B **7 birim kare**
C **12 birim kare**
D **17 birim kare**