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Improving the Understanding of Grade 11 ICT Learners on Function Operations through the Use of Colored Pens as Visual Aid

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Abstract: This study aimed to increase the level of understanding on function operations of the Grade 11 ICT learners of the Sto. Rosario National High School through the use of colored pens as visual aids. Specifically, it sought answers to the following questions: 1) What is the level of performance of the learners before and after the intervention?; 2) What is the mean gain difference in the level of performance of the learners before and after the intervention?; and 3) Is there a significant difference between the level of performance of the learners before and after the intervention? The study made use of true-experimental design two group research design particularly the pretest-posttest design. Data were gathered through a research instrument which have undergone validation and reliability test. Salient findings were the following: 1) the level of performance of the students both groups improved into average and high; 2) there is an increase on the mean gain difference of both groups; and 3) there is a significant difference between the posttest scores of the control group and the experimental group.
Keywords: Level of Understanding, Worksheets, Colored Pens

I. INTRODUCTION

Operations on functions—such as addition, subtraction, multiplication, division, and composition—are important skills that senior high school students need to learn in mathematics. However, many students find these topics difficult because they involve many steps and abstract ideas. Based on data from the Department of Education (2020), math is often one of the lowest-performing subjects in national and classroom tests. Many students struggle to remember algebra procedures and get confused when solving problems with multiple steps [2]. A study by Bautista (2018) found that more than 60% of Grade 11 students made mistakes when solving problems about function operations. These included not knowing how to combine functions properly or how to find the correct domain. This shows a bigger problem: many students have trouble understanding and remembering math concepts, especially in topics like functions [4].

One reason for these difficulties is that students' brains can get overwhelmed when working with complex symbols without visual help [5]. Without good teaching strategies to guide them, many students just try to memorize steps or guess. Using only black-and-white materials can make it harder for students to see how each part of a function connects with the others.

To help solve this problem, this study suggests using colored pens as a simple tool to improve learning. Research shows that color helps students focus, understand better, and remember information [6]. If different colors are used for different parts of a function or operation, it becomes easier for students to see, compare, and understand each step [7].

Color coding also helps students break down complex problems into smaller, clearer parts. According to van der Meij et al. (2023), students who learned from materials with color did better and felt less stressed than those who used plain black-and-white materials. Color can also help students who have attention problems stay focused and avoid distractions [9].

Still, some researchers warn that using too much color can make students depend on it too much. When color is removed, they might struggle again—a problem known as the guidance reversal effect [10]. That's why the use of color in this study will be reduced slowly over time, helping students eventually solve problems without needing color support.

In short, this research aimed to improve students' understanding of operations on functions by using color pens as a visual aid. This simple strategy could help make math clearer, reduce confusion, and build students' confidence in solving problems.

There has been lack of literature in using the same strategy for the researcher to address learning competencies in his subjects being taught. As reflected from the results of their first summative test after three long weeks, it was found that the percentage of mastery was very low. The teacher-researcher gained the following results: 39% for the Humanities and Social Science, 42% for the

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Accountancy and Business Management, and 33% for the Technical-Vocational and Livelihood-Information and Communications Technology.

Hence, the researcher proposed the use of colored pens to address the pre-requisite skills needed to perform the different operations of functions.

II. METHOD

A. Research Design

The design used in the study was true-experimental two group research design particularly the pretest-posttest design which allows the researcher to manipulate and control one or more independent variables [11]. This is appropriate for the study since the researcher intended to determine the effectiveness of the intervention by comparing the pretest and posttest scores of the experimental and control groups.

B. Participants

Two groups of randomly selected ICT and HUMSS learners of Sto. Rosario National High School of School Year 2025-2026 took part in the study. 15 from 11-Gates (Experimental Group) and 15 from 11-Confucius (Control Group) participated in the study. He asked the consent and contact details of the parents in both groups.

The control group were exposed to lecture method while the experimental group utilized the colored pens and worksheets on operations on functions. Also, the researcher monitored the progress of each learner in the experimental group through the captured pictures of answered worksheets, and other documentations. Lastly, he asked his learners to write a paragraph about the effects of learning from the series of intervention.

C. Instrumentation

This study used colored pens as a teaching tool to help students better understand operations on functions. First, before starting the intervention, students took a pretest to check how much they already know about function operations—like adding, subtracting, multiplying, dividing, and composing functions. Then, the teacher explained how to use colored pens in solving problems. A color code was introduced and used in all lessons—for example, blue for terms with x2, red for terms with x, and greed for constants. These color guides helped students clearly see which parts of a problem they are working on.

The main part of the intervention lasted three to four weeks. During this time, the teacher assisted learners to solve problems using the assigned colors step by step. Students used colored pens while solving practice exercises in class. By using different colors, students were able to organize their work better, avoid confusion, and remember the steps more easily. Studies show that color can help students pay more attention, reduce confusion, and improve memory and understanding in learning tasks [6], [7]. It also helped lighten mental effort, especially when solving problems with many steps or symbols [5], [8].

While students worked on the exercises, the teacher observed how well they used the color method and gave feedback as needed. Students also were encouraged to write short reflections about how the use of color have helped them. At the end of the intervention, a posttest was given to measure what they've learned. Their test results before and after the intervention were compared to see if they improved. Students were also asked to give feedback on their experience using colored pens—either through a simple survey or small group discussion.

In the final week, the use of color was slowly reduced. Students first used fewer colors, and eventually went back to solving problems using just one color. This step was important because some students may become too dependent on color, which might make it harder for them to work on problems without it later on [10]. The goal was to help students learn how to solve problems independently, even without the colored cues.

The researcher administered pretest-posttest before and after the treatments. The research instrument was a 60-item test crafted from the topic on Operations of Functions. The test has undergone validation among three Master Teachers from the Division of La Union. After incorporating the suggestions, the test was administered for pilot testing to the same school with another ICT class which are deemed to have similar characteristics to the intended respondents of the study. 30 learners were selected to participate in the said reliability test of the instrument where results were treated using Kuder-Richardson-20. Moreover, the research instrument obtained 5.0 which can be interpreted with very high validity based from the scale on level of validity set by Quinay (2008). Also, the researcher used the Kuder-Richardson Formula 20 to test the reliability of the instrument. It was found out that the instrument is highly reliable with 0.82 reliability coefficient based from the scale on level of reliability set by Espinueva (2012).

To describe the validity of the created instructional video, the researcher devised the following table:

TABLE I
Scale on the Level of Validity

Point Value	Statistical Range	Description Equivalent Rating
5	4.20-5.00	Very High Validity
4	3.40-4.19	High Validity
3	2.60-3.39	Moderate Validity
2	1.80-2.59	Slight Validity
1	1.00-1.79	Poor Validity

TABLE II.
Scale on the Level of Reliability

Statistical Range	Description Equivalent Rating
0.90-1.00	Very High Reliability
0.70-0.89	High Reliability
0.40-0.69	Substantial Reliability
0.20-0.39	Definitely Reliability
0.00-0.19	Negligible Reliability

D. Data Analysis

The data gathered were collated, organized, tallied, and presented in tables to ensure accuracy, order, and for the systematic evaluation of the data. The researcher devised a scale to determine the level of performance among the participants. He calculated the difference of the average posttest score and average pretest score of both the control group and the experimental group to determine the mean gain difference. t -test was also used to determine the significant difference between the control group and the experimental group.

III. RESULTS

A. Level of Performance of the Control Group and the Experimental Group Before and After the Treatment

Table 1 shows the performance of the control group and the experimental group in the pretest and posttest. Both groups have improved their performance from low understanding into average understanding for the control group and into high understanding for the experimental group.

TABLE III.
Level of Performance of the Control Group and the Experimental Group

Control Group			Experimental Group		
Participant	Pretest	Posttest	Participant	Pretest	Posttest
1	19	30	1	35	45
2	17	26	2	21	36
3	18	28	3	20	37
4	24	33	4	16	34
5	26	31	5	14	35
6	22	30	6	28	35
7	19	30	7	26	42

Control Group			Experimental Group		
Participant	Pretest	Posttest	Participant	Pretest	Posttest
8	26	28	8	24	35
9	16	27	9	19	35
10	19	31	10	25	36
11	22	25	11	29	36
12	34	38	12	20	40
13	13	26	13	30	38
14	26	28	14	20	38
15	27	32	15	22	33
Mean	22	30	Mean	23	37
Standard Deviation	5.38	3.31	Standard Deviation	5.67	3.21
Description	Low Understanding	Average Understanding	Description	Low Understanding	High Understanding

B. *Mean Gain Difference between the Performance of the Learners in the Control Group and the Experimental Group Before and After the Treatment*

Posttest results revealed the following: the Control Group gained a Mean of 30 and a standard deviation of 3.31 which can be described as Average Understanding and the Experimental Group gained a mean of 37 and a standard deviation of 3.21 which can be described as High Understanding.

Both groups improved after instruction; however, the magnitude of improvement differed considerably. The Control Group gained +8 points and the Experimental Group gained +14 points. Particularly, the Experimental Group outperformed the Control Group by 7 points in posttest mean (37 vs. 30) and 6 points in learning gain (14 vs. 8). This suggests that the intervention had a meaningful positive effect.

C. *Significant Difference between the Performance of the Learners in the Control Group and the Experimental Group Before and After the Treatment*

Table 2 shows no significant difference between the control group and the experimental group before the treatment since the p-value of 0.8539 is greater than 0.05. This only means the two groups of selected participants have equal performance before they utilized the modules and tutorial videos on limits and continuity.

TABLE IV.
Difference between the Performance of the Learners in the Control Group and the Experimental Group Before and After the Treatment

	t-stat	**T-critical**	**P(T<=t)**		**Remarks**
Before	0.4433	2.0484	0.6609578	0.05	Not Significant
After	6.2708	2.0484	0.0000008	0.05	Significant

IV. DISCUSSION

A. *Level of Performance of the Control Group and the Experimental Group Before and After the Treatment*

Table 1 shows that most of the scores of the participants in both groups displayed a significant increase to their posttest. This implies that they learned from the materials they were exposed to. Most of the scores of the participants in both groups displayed a significant increase to their posttest. This implies that they learned from the materials they were exposed to. Most of the participants in the control group have significant increase in their posttest scores which can be attributed to the lecture method. Meanwhile, the same situation happened to the experimental group where most of the participants doubled their posttest scores which can be highly attributed to the use of colored pens as visual aids.

It can be gleaned from the table that both groups demonstrated Low Understanding prior to the implementation of the intervention. The one-point difference in the mean scores indicates that the groups were relatively comparable at baseline. The similar standard deviations further suggest that both groups exhibited nearly the same variability in performance.

This baseline equivalence strengthens the internal validity of the study because any posttest differences can more reasonably be attributed to the intervention rather than pre-existing differences [14].

From a theoretical standpoint, the low pretest performance may reflect limited prior knowledge or insufficient mastery of prerequisite concepts. According to David Ausubel's Theory of Meaningful Learning, new knowledge is learned effectively when it connects to relevant prior knowledge. If learners possess weak foundational schemas, comprehension becomes superficial. The low pretest means suggest that students may not have had sufficiently developed cognitive structures to anchor new learning.

Similarly, Jean Piaget emphasized that learners construct knowledge based on developmental readiness. The results imply that students may have been in the early stages of conceptual construction, necessitating structured and guided instruction.

Both groups showed reduced variability from pretest to posttest: Control Group had a standard deviation from 5.38 to 3.31 while the Experimental Group had a standard deviation from 5.67 to 3.21. This decrease indicates the earning gaps narrowed, the instruction helped weaker students improve; and the intervention may have promoted equitable learning.

According to Benjamin Bloom (Mastery Learning Theory), effective instruction reduces variability in student achievement because most learners can achieve mastery when given proper time and support. The reduced spread of scores in the Experimental Group strongly reflects this principle.

B. *Mean Gain Difference between the Performance of the Learners in the Control Group and the Experimental Group Before and After the Treatment*

The Experimental Group achieved a substantially higher mean and moved from Low to High Understanding, while the Control Group reached only Average Understanding.

The improvement in both groups suggests that instruction—regardless of method—contributed to learning. However, the greater improvement in the Experimental Group indicates that the intervention provided added instructional value.

This finding aligns with John Hattie's (2009) synthesis of meta-analyses, which found that instructional strategies emphasizing feedback, active engagement, and clear learning intentions produce higher effect sizes compared to traditional methods. If the intervention incorporated structured engagement or interactive components, this may explain the substantial gain.

Furthermore, Lev Vygotsky's Social Constructivist Theory posits that learning occurs most effectively within the Zone of Proximal Development (ZPD) through scaffolding and guided interaction. The higher posttest mean of the Experimental Group suggests that the intervention may have provided structured scaffolds that allowed learners to perform beyond their independent capabilities.

C. *Significant Difference between the Performance of the Learners in the Control Group and the Experimental Group Before and After the Treatment*

Table 2 shows significant difference between the control group and the experimental group before the treatment since the p-value of 0.6609578 is greater than 0.05. This only means the two groups of selected participants have equal performance before they were exposed to the instructions.

After the treatment, there was a significant difference between the control group and the experimental group since the p-value of 0.0000008 is less than 0.05. This implies that the learners in the experimental group more effectively learned from the colored pens as visual aid than those taught using the lecture method.

The result is consistent with the work of Lev Vygotsky, who emphasized the importance of scaffolding and social interaction in learning. If the intervention involved collaborative, guided, or scaffolded learning experiences, the higher gains may reflect movement within the learners' Zone of Proximal Development (ZPD).

Additionally, Jerome Bruner advocated discovery-based and structured learning environments, which promote deeper conceptual understanding. The Experimental Group's shift from Low to High Understanding suggests conceptual development rather than mere memorization.

V. CONCLUSIONS

The data indicate that: 1) Both groups began at comparable levels of understanding; 2) Instruction improved learning in both groups; 3) The Experimental Group demonstrated significantly greater improvement; and 4) The intervention led to higher achievement and reduced performance variability.

The results suggest that the implemented strategy enhanced not only achievement levels but also conceptual understanding and equity in learning outcomes. From a constructivist perspective, learning is optimized when students actively construct knowledge rather than passively receive information. The higher mean gain in the Experimental Group implies that the intervention likely fostered deeper cognitive processing, consistent with constructivist and socio-cultural learning theories.

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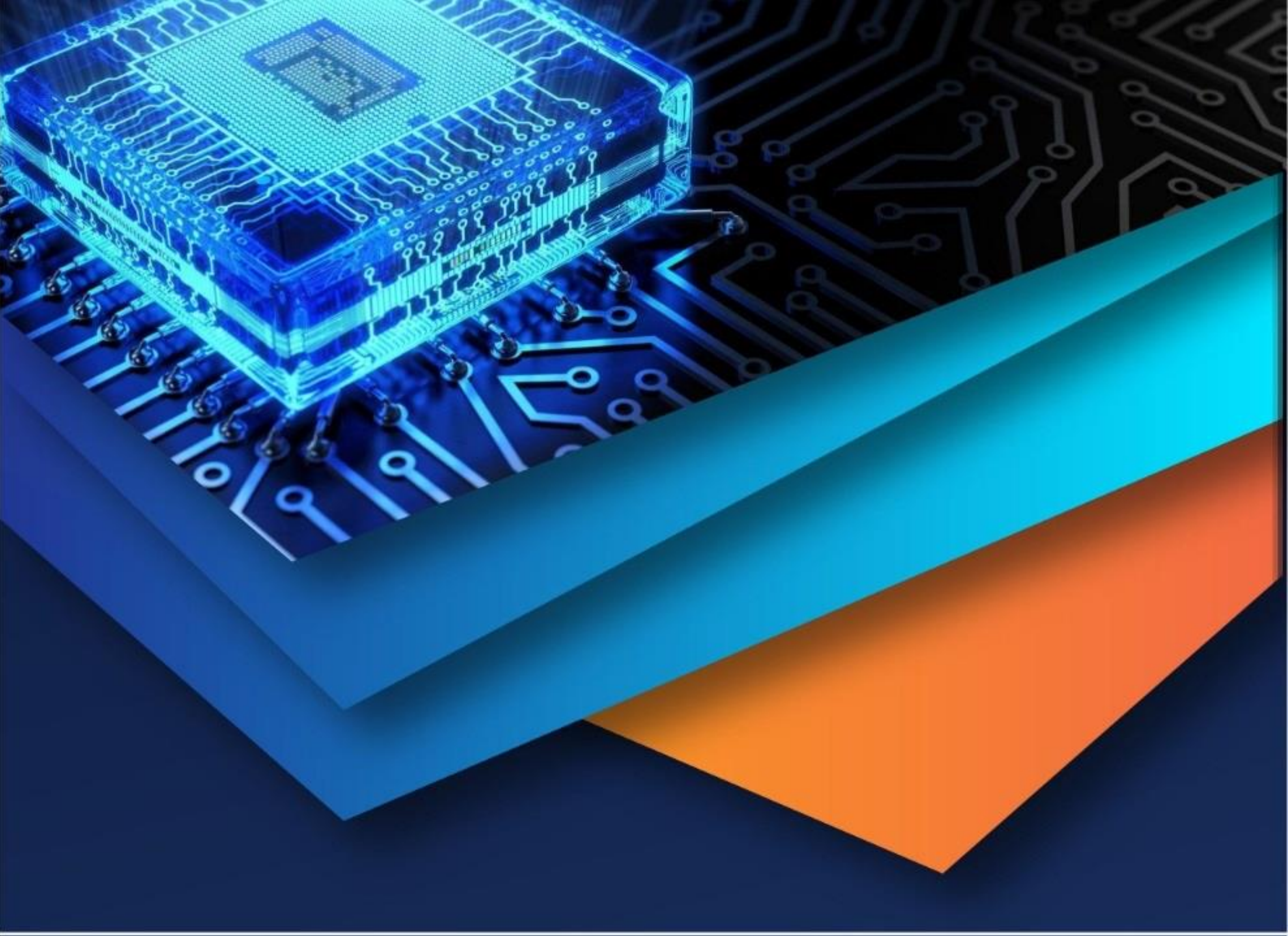

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