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Research Article

Promoting Students' Conceptual Understanding through Directive Teacher Guidance and Non-directive Teaching Model in a Collaborative Problem Solving

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ABSTRACT

This study examined and aimed to promote students' level of conceptual understanding in problem-solving through Directive Teacher Guidance (DTG) and the Non-directive Teaching Model (NDTM). The study employed sequential-explanatory mixed research using quasi-experimental switching replication treatment involving quantitative and qualitative data. Two groups of Grade 8 high school students were used as participants in the study. One group had 36 students, and the other had 38 students exposed to DTG and NDTM approaches. Quantitative data were obtained from the scores of students from the pretest, first posttest, and second posttest about the topics in Mathematics subject. Qualitative data were from the analysis of participants' responses in problem-solving, focus group discussion, and classroom observation. The t-test for the dependent sample was utilized to determine the significant change in students' level of conceptual understanding after the first and second implementation phases, while the t-test for the independent sample was used to find out the significant difference between the pretest and posttests between the two groups. Results showed that students' conceptual understanding and problem-solving skills significantly improved after exposure to the two approaches. The two groups' levels of conceptual understanding in switching replication treatment are found to have no significant difference. Moreover, participants preferred guided questions and guided directions and believed in the importance of attaining a conceptual understanding of the lesson. It is suggested to integrate DTG and NDTM as teaching strategies and conduct a study considering a longer span of implementation to determine the effectiveness of the two approaches.

Keywords: *Collaborative problem solving, Conceptual understanding, Directive teacher guidance, Non-directive teaching model, Switching replication treatment*

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Introduction

In the last 2018 Program for International Students Assessment (PISA), according to the Department of Education on the PISA 2018 National Report of the Philippines, Filipino students achieved an average score of 353 points in Mathematical Literacy, which was significantly lower than the Organization for Economic Co-operation and Development (OECD) average of 489 points. According to the reports, only one (1) out of every five (5) Filipino students achieved at least the minimum level of mathematical literacy. Hence, the challenge is for the teachers how to present the lessons that facilitate effective learning. Another challenge was when the CoViD-19 pandemic significantly affected the Philippine educational system. The importance of education requires both teachers and students to adopt a new classroom setup that differs from the traditional one that we are all used to but doesn't leave the role of students and teachers in the learning process.

Teachers are encouraged to adopt different teaching methods and approaches to challenge, inspire, and engage students to learn and be participative in a mathematics online learning classroom. Moreover, the students must grasp the real meaning of the mathematical ideas for better performance and application of knowledge in real-life contexts, which is defined as a conceptual understanding by the National Research Council (NRC, 2001). Many authors had studied and defined conceptual understanding in Mathematic: it is knowing more than the isolated facts and methods (Andrew, 2016); it is where the students can grasp ideas in a transferrable way and can help learners take what they learn in class and apply it across domains (Omari & Chen, 2016); the ability of the learners to reconstruct the forgotten concepts or construct their own procedures for finding answers when memory fails (Mangilit, 2013); and it is when the students sufficiently know all the relevant concepts and their mutual interrelations (Budé et al., 2011). In addition, the Science Education Institute & Mathematics Teacher Education and the Philippine Council of Mathematics Teacher Education (SEI-DOST & MATHTED, 2011) have claimed that the ability to explain and solve a problem is evidence of a good understanding of mathematical ideas, teaching Mathematics requires more that these and thorough comprehension requires a variety of learning tools. If the learner has acquired genuine conceptual understanding, they can apply their ideas and recognize how a single concept may affect a mathematical solution. It also promotes longer retention and avoids misconceptions of ideas. The teacher can help improve their student's learning experience and promote their critical thinking and problem solving skills by improving their questioning techniques, utilizing more differentiated techniques and strategies for various types of learners, and focusing more on emphasizing the application in real-world settings (Dicdiquin, 2023).

As a response to attain one of the goals of K to 12 Mathematics education, which is to strengthen the students' conceptual understanding two teaching approaches namely Directive Teacher Guidance (DTG) and Non-Directive Teaching Models (NDTM) were utilized in the study. The teacher provides directive guidance to students by giving guided questions and directions that help the learners reinforce their knowledge and retrieve what they already know. On the other hand, non-directive teaching helps the learners become independent learners.

Directive guidance is when the teacher clearly states what the students are supposed to do (Bergqvist et al., 2015). It emphasized that if the teacher is more actively guiding the process in a directive way, it will become error-free, and students are indeed engaged in their learning process. According to Abbot (2013), direct instructions refer to instructional approaches that are structured, sequenced, and led by teachers. The guiding principle of direct instruction is that every student can learn if the teacher carefully leads them. It was mentioned that directing style promotes learning by way of encouraging students to listen and follow directions (Thornton, 2013). In this style, students are instructed on what to do, how to do it, and when it needs to be done. Providing the students with information that thoroughly explains the concepts and procedures and teachers attempt to persuade students' misconcep-

tions or processes on topics when they are having difficulties (Kirshner et al., 2010). The role of the teacher is to guide students directly so that when they are committing errors, the teacher will guide the students to correct answers by providing another guided question. Asking directive questions as soon as the student went astray or providing them with guided directions (Budé et al., 2011). This will encourage the students to engage and actively think about their learning. Nevertheless, Dean and Kuhn (2006) have called for a rethink on direct guidance because they found out that the effects of direct instruction existed shortly after instruction but did not last for a long time, which indicates that conceptual understanding is not achieved. In addition, when the teacher frequently offers too much direct assistance, such as giving all the information required to solve mathematical problems or performing the most challenging part of the lesson may deprive students' opportunity to learn and think. Heick (2016) had mentioned also that direct instruction – whether by whole-class lecture or one-on-one compulsion- is not the most progressive learning style in the world, but it may have a role.

Students who are independent learners can be successful by all means; with or without assistance, they can comply with what is required. If the students are given the freedom to express themselves and explore, they can achieve their best results. The NDTM is when the teacher listens as the student delves into their restricted emotions and realizes a solution to their problem rather than giving advice (Gonzales, 2017). It will let students learn the cause and effect of their choices and understand their behavior. The NDTM allows students to express their feelings and encourages them to define their problems, discuss their concerns, make decisions, plan for future positive actions, and act out positive ones (Fisher, 2013). It points out that in this model learners are responsible for their learning. It produces the students' effort from start to finish (Petersen, 2015). Students create plans to learn a new task and realize that their progress in reaching their goal is directly linked to their effort. Transfer of learning on the NDTM is based on students' learning plans. But it doesn't mean that teachers will give up their responsibility; they just let the students be in their own direction and method. Dicdiquin et al. (2023) mentioned that if teachers are more likely to display the proper way to solve a problem students may not have as much opportunity to develop their problem solving skills independently and this could limit students' ability to think critically and creatively. Meanwhile, almost all the studies about unguided and guided mostly support direct, strong instructional guidance rather than the constructivist-based minimal guidance during the instruction of novice to intermediate learners, and their basis for their study claimed that it is consistently indicated that minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on the guidance of the student learning process (Kirshner et al., 2010).

Conceptual understanding is evidently attained if the students can associate learning with real-life situations. Since many students find Mathematics problem-solving difficult, Tumilty (2016) found that guided instruction strategies are based on authentic and realistic learning experiences that improve higher-order thinking skills. Moreover, guided instructions include a social component, allowing students to engage with their classmates, exchange ideas, and learn how to collaborate towards a common objective. The recent study incorporated new approaches by providing guided questions and directions or by letting students discover and learn on their own in answering Mathematics problems and in dealing with real-life situations. These will help students develop critical thinking, creativity, communication, and collaboration. Critical thinking and creativity can be set in students as they solve mathematics problems and real-life situations. In these skills, students must retrieve previous information on how they will go for a solution. Through collaborating with other people, communication may take place as students share their ideas. In the present study, the proper guidance directly from a teacher through questioning or by giving the students the chance to learn and discover on their own, collaboratively doing problem-solving in mathematics may be less complicated and can

strengthen their conceptual understanding of the related topic. Therefore, the study aimed to investigate how DTG and NDTM in collaborative problem solving contribute to the enhancement of students' conceptual understanding of Mathematics. Particularly, the study sought answers to the following questions:

1. How may the students' level of conceptual understanding be described based on the pretest, first posttest, and second posttest results of the two groups using switching replication treatment in the approach directive teacher guidance (DTG) and non-directive teaching model (NDTM)?
2. Is there a significant difference between the two groups' mean score results in the pretest, first posttest, and second posttest?
3. Is there a significant change between the two groups' levels of conceptual understanding before and after their exposure to DTG and NDTM?
4. What are the students' level of conceptual understanding in problem-solving and their perception of the implementation of DTG and NDTM?

Methods

Research Design

Switching replication quasi-experimental design was employed in the study to investigate how can DTG and NDTM in collaborative problem solving contribute to the enhancement of students' conceptual understanding of Mathematics. This research design is conducted to evaluate the effectiveness of treatment in two groups at different time intervals. So, by the end of the study, all participants have received the same treatment. Both quantitative and qualitative data analyses were taken into account to obtain substantial information on the efficacy of the two teaching approaches. The teacher-researcher implemented the two teaching approaches simultaneously in different groups and at different times.

Research Locale and Participants

Two sections of Grade 8 high school students in a state university in Bulacan, were involved in the study. Group 1 consists of thirty-eight (38) students and Group 2 consists of thirty-six (36) students who were the participants of the study, both sections belong to the synchronous mode of learning since implementation should happen in real-time. The participants in the two sections were formed into six collaborative groups in each section. The study was implemented in their Mathematics class schedule, under the facilitation of the teacher-researcher.

Research Instruments

The instruments used were the pretest, first posttest, second posttest, collaborative activity sheet, focus group discussion, and STAR observation Technique. The tests were adapted from the Grade 8 learner's module under K to 12 Curriculum. It is validated by expert mathematics teachers from other schools. The pretest was given to the participants to measure their prior knowledge and initial comparability in their level of conceptual understanding of the topics. The first posttest was administered to the participants to evaluate the students' level of conceptual understanding during the first phase of the implementation and if DTG and NDTM in collaborative problem-solving are effective. The result of the second posttest was to measure the students' level of conceptual understanding, determine the difference in the treatment effect of each group, and determine the impact on the student's conceptual understanding maintained after the switching. Problem solving parts comparable to the pretest were considered and evaluated to determine whether the level of conceptual understanding of participants improved. The collaborative activity sheets are activities designed by the teacher-researcher. Guided directions and guided questions were included for participants under DTG in collaborative problem solving to help the students answer a specific mathematical problem. Participants in NDTM answered mathematical problems and activities based on their understanding and prior knowledge. The participants answered the activity sheets collaboratively with their assigned group members. The focus group discussion was done after the implementation of the two teaching approaches, and analysis of scores in problem solving of the participants. Students were asked questions about their perception of the implementation of the two teaching

approaches. And, STAR Observation technique, a supervisory tool used by the Department of Education, to collect information from actual learning activities in the classroom. The researcher asked the observers to answer this observation rubric during the implementation of DTG and NDTM in a collaborative problem solving.

Research Procedures

Prior to the implementation of the study, the researcher prepared a letter to the principal requesting to conduct the study it is followed by an orientation to inform the purpose of the study. The pre-test was administered to assess their conceptual understanding and check their prior knowledge and skills about the topic prior to the implementation of the two teaching approaches in the two groups. In the first phase of implementation, Group 1 was treated using the DTG approach and Group 2 was treated using the NDTM approach both in collaborative problem solving. This is followed by administering the first posttest about the covered lesson to determine the effectiveness of the two teaching approaches. Switching replication was done before the second phase of implementation. Two groups exchange approaches wherein Group 1 was treated using the NDTM approach and Group 2 was treated using the DTG approach, which was different from the first phase of implementation. The second posttest was administered after the coverage of lessons in the second phase to determine if the effectiveness of the two teaching approaches is maintained and if there is a change in the students' level of conceptual understanding. A focus group discussion was scheduled with seven randomly chosen students, they were asked about the implementation of the teaching strategy to support the quantitative findings and it is accompanied by the observation of classes. The study took 13 sessions, a maximum of 9 sessions to implement the two teaching approaches.

Data Analysis

The determine students' level of conceptual understanding of the two groups' pretest scores, first posttest scores, and second posttest scores was assessed using the t-test for two independent samples. It is to compare their initial conceptual understanding of the topic under consideration. The frequency distribution of students based on their level of conceptual understanding was also used to describe the results of the tests thoroughly. The latest education curriculum, K to 12, proficiency levels served as the reference in describing the students' level of conceptual understanding, as also used by Andamon and Tan (2018). If the obtained score is 27.51 – 35 it is classified as advanced level, 23.51 – 27.50 proficient level, 20.51 – 23.50 approaching proficiency level, 16.51 – 20.50 developing level, and 1 – 16.50 beginning level, this is patterned with the study of Villanueva (2017). While to assess the magnitude of the intervention, Cohen's *d* was used to determine the effect size on the students' conceptual understanding in the implementation of the two approaches and strengthen the result from the t-test. The significant results from statistical treatment determine if the intervention works, whereas the effect size reveals how much it works. The t-test for paired samples for means was used to determine the significant difference between the two groups exposed to different teaching approaches by comparing the scores of participants on questions that are parallel in the pretest and first posttest. Moreover, using the same statistical treatment, the participants' scores on items parallel in the pretest and second posttest were compared. It was to find out if the students' level of conceptual understanding changes after the first and second phases of implementation and no intention of finding which group has a higher result. Meanwhile, students' responses in the focus group discussion were transcribed and subjected to thematic analysis patterned with Braun & Clarke (2006).

Result and Discussion

The frequency distribution, mean scores, and variability were used to interpret the level of conceptual understanding of the two groups.

Table 1. Group 1 Level of Conceptual Understanding

	Frequency					Mean Score	Variance	Interpretation
	Level of Conceptual Understanding							
	A	P	AP	D	B			
Pretest	0	0	0	1	37	7.53	14.04	Beginning
First Posttest	9	7	7	3	12	21.68	63.83	Approaching Proficiency
Second Posttest	6	10	8	5	9	21.37	48.40	Approaching Proficiency

n=38, Level of Conceptual Understanding (A-Advanced; P-Proficient; AP-Approaching Proficiency; D-Developing; B-Beginning)

The result as shown in Table 1, indicate that the level of conceptual understanding of students in Group 1 prior to the implementation is at the beginning level ($\bar{x}$ = 7.53), and moved up to Approaching Proficiency level in the first posttest ($\bar{x}$ = 21.68) and second posttest ($\bar{x}$ = 21.37). It implies that Group 1 has improved its conceptual understanding using the two teaching approaches.

Table 2. Group 2 Level of Conceptual Understanding

	Frequency					Mean Score	Variance	Interpretation
	Level of Conceptual Understanding							
	A	P	AP	D	B			
Pretest	0	0	0	0	36	8.42	11.34	Beginning
First Posttest	16	8	2	1	9	23.75	65.91	Proficient
Second Posttest	10	8	4	7	7	22.19	48.50	Approaching Proficiency

n=36, Level of Conceptual Understanding (A-Advanced; P-Proficient; AP-Approaching Proficiency; D-Developing; B-Beginning)

Table 2 shows the level of conceptual understanding of the participants in Group 2. Before the implementation of the two approaches the Group 2 level of conceptual understanding is at the beginning level ($\bar{x}$ = 8.42). After the first phase of implementation, it reached the proficient level ($\bar{x}$ = 23.75). which implies that their level of conceptual understanding has significantly improved. The level of conceptual understanding of Group 2 falls by 1 level at the second phase of implementation which is at the approaching proficiency level ($\bar{x}$ = 22.19). It means that participants received higher scores during the first posttest than on the second.

These findings from Tables 1 and 2 evidently showed that DTG and NDTM were effective, and participants enhanced their level of conceptual understanding. This strengthens the study of Budé et al. (2011) that students score considerably better when guided with questions and directions. In addition, the positive result of the study of Firdaus et al. (2017) and Wang (2019) is that direct instructions increase the student's ability to relate mathematical concepts in solving problems, and non-directive teaching has more advantages, respectively, supporting the result. In addition, it also reinforces the study of Bakaç and Taşoğlu (2014) using small collaborative groups in activities involving problem scenarios with guidance from a teacher to improve students' conceptual understanding.

To determine the significant difference in the two groups' level of conceptual understanding, the mean score result of participants for the pretest, first posttest, and second posttest was computed and presented in the following tables. The t-test for two independent samples was used.

Table 3. Mean Distribution of the Test Scores of the Two Groups in the Pretest

	Mean Scores	Test Statistics	*p*-value	t-critical value	Interpretation
Group 1	7.53	1.07	0.29	1.99	No significant difference
Group 2	8.42				

At α = 0.05, df = 72

The result presented in Table 3 indicated that there is no significant difference (t = 1.07, p > 0.05) between the pretest scores of the two groups. These results were reinforced by the computed mean scores of the two groups' pretest in Tables 1 and 2, which implies that they have little idea about the lessons. It can be concluded that the two groups had the same level of conceptual understanding prior to the implementation of the two teaching approaches.

Table 4. Mean Distribution of the Test Scores of the Two Groups in the First Posttest

	Mean Scores	Test Statistics	*p*-value	Interpretation	Cohen's *d*	Interpretation
Group 1	21.68	1.08	0.28	No significant difference	0.25	Medium Effect
Group 2	23.75					

At α = 0.05, df = 72, t critical value = 1.99, effect size (Cohen's d) value 0.10 (small effect), 0.20 (medium effect), 0.40 (large effect)

The table showed no significant difference (t = 1.08, p > 0.05, $t \leq 1.99$) between the two groups' first posttest after exposure to DTG and NDTM in the lessons about the system of linear equations. It implies that the two groups are equally the same regarding their first posttest. However, the mean difference between the two groups' first posttest has a medium effect size (d = 0.25). It indicates that DTG and NDTM have a moderate relationship. Even if it is not significant, one approach has a minimal advantage in terms of the two groups' mean scores in the first posttest. Both groups enhance their conceptual understanding, and the implementation of DTG and NDTM in collaborative problem solving is effective.

Table 5. Mean Distribution of the Test Scores of the Two Groups in the Second Posttest

	Mean Scores	Test Statistics	*p*-value	Interpretation	Cohen's *d*	Interpretation
Group 1	21.36	0.51	0.61	No significant difference	0.12	Small Effect
Group 2	22.19					

At α = 0.05, df = 72, t-critical value = 1.99, effect size (Cohen's d) value 0.10 (small effect), 0.20 (medium effect), 0.40 (large effect)

The result of Table 5 indicated that the difference between the second posttest results of the two groups in the lessons on linear inequalities and the system of linear inequalities is not significant (t = 0.51, p > 0.05, $t \leq 1.99$), with a small effect size (d = 0.12). Therefore, the two groups' second posttest results are also equally similar after switching the two teaching approaches.

The first implementation phase covers the lessons on the system of linear equations in two variables wherein the two groups were treated using different approaches. The performance of the participants on the parallel questions of the pretest and first posttest were compared to determine the effectiveness of the two approaches. The t-test for the paired sample was used to determine if there is a change in students' level of conceptual understanding.

Table 6. Test Statistics results of the Two Groups on the First Phase of Implementation

		Mean Scores	Test Statistics	Degree of freedom	*p*-value	Interpretation
Group 1	**Pretest**	3.53	10.42	37	0.00	Significant difference
	First Posttest	9.82				
Group 2	**Pretest**	4.47	9.20	35	0.00	Significant difference
	First Posttest	10.89				

At α = 0.05, t-critical value = 2.03

The result presented in Table 6 indicated a statistically significant difference ($p = 0.00$, $p < 0.05$). The computed test statistics ($t_1 = 10.42$, $t_2 = 9.20$) of the two groups for their pretest and first posttest are both greater than the t-critical value of 2.03; this implies that the first posttest of both groups is significantly higher than their pretest scores. It is evident in Tables 1 and 2 that both groups enhance their level of conceptual understanding at the end of the first phase of implementation, which means that the two teaching approaches, such as DTG and NDTM, are effective. On the other hand, in the second implementation phase, the switching replication treatment was applied where the two groups exchanged approaches. The performance of the participants on the parallel questions on the pretest and second posttest about the mentioned lesson were compared to determine again the effectiveness of the two approaches and if there is a change in students' level of conceptual understanding.

Table 7. Test Statistics results of the Two Groups on the Second Phase of Implementation

		Mean Scores	Test Statistics	Degree of freedom	*p*-value	Interpretation
Group 1	**Pretest**	4.00	11.43	37	0.00	Significant difference
	Second Posttest	11.16				
Group 2	**Pretest**	3.94	12.95	35	0.00	Significant difference
	Second Posttest	11.50				

At α = 0.05, t-critical value = 2.03

The result presented in Table 7 indicated a statistically significant difference ($p = 0.00$, $p < 0.05$). The computed test statistics ($t_1 = 11.43$, $t_2 = 12.95$) of the two groups for their pretest and second posttests are greater than the t-critical value of 2.03; this implies once more that the second posttest for both groups is significantly higher than the pretest score. It also reinforces the results in Tables 1 and 2 that both groups enhance their level of conceptual understanding from the Beginning Level to the Approaching Proficiency Level at the end of the second phase of implementation.

The findings in Tables 6 and 7 confirmed that there are significant changes in students' level of conceptual after the implementation of the two teaching approaches. In summary, it is remarkable that DTG and NDTM both promote students' conceptual understanding. Results in the quantitative findings showed that students' level of conceptual understanding prior to the implementation is at the Beginning Level and move up to the Approaching Proficiency Level at the end of the study, which is based on their mean test scores. It is also supported by the test statistics that students' conceptual understanding greatly improved after being subjected to the two teaching approaches. Nevertheless, it does not reach the highest level of conceptual understanding. This finding is the same as the outcome of Kirshner et al. (2010) study that students with considerably prior knowledge, and strong guidance from a teacher while learning is most often found to be equally effective as unguided approaches. Additionally, it proved that using collaborative teaching methods and the use of activity sheets (Pedrosa, 2014) improved students' conceptual

understanding and helped weak students end up with a complete mastery of learning concepts The two teaching approaches continued to show effects after it was switched. This is a response to the suggestion of Montero et al. (2022) in developing and producing instructional materials such as worksheets that are localized and contextualized learning activities that play a significant role in improving the conceptual understanding of the learners. Thus, if more meaningful learning activities are to be given to the students, more learning would be acquired.

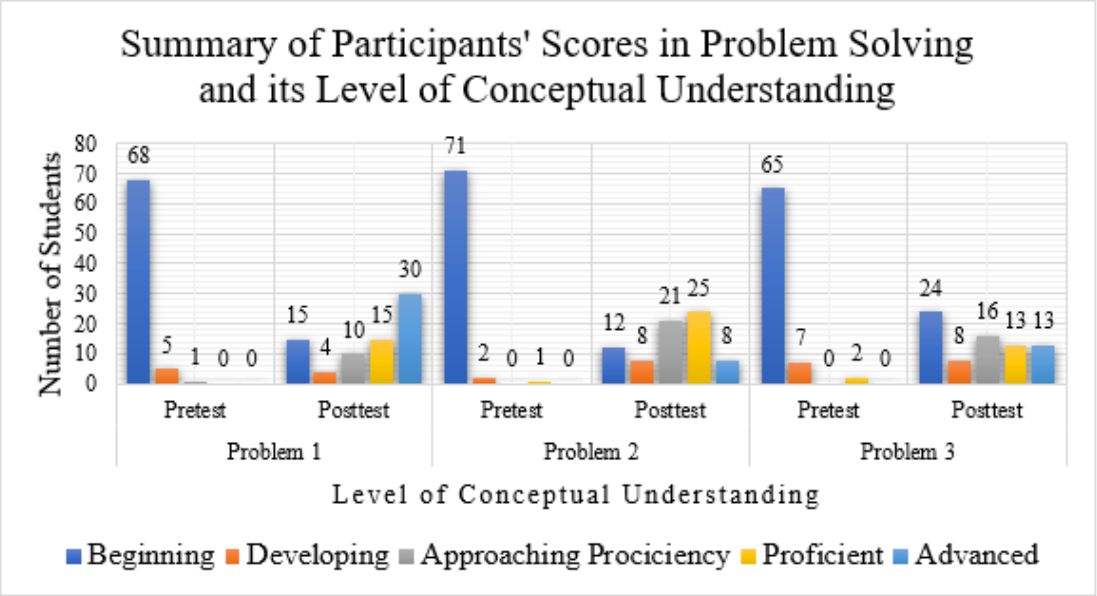

Figure 1. Summary of Participants' Scores and Level of Conceptual Understanding in Problem Solving

The summary of participants' scores in comparable items in problem solving in the pretest and posttests of the two groups and tallied and compared based on students' levels of conceptual understanding is shown in Figure 1. Obviously, as shown in Figure 1, the majority of the participant's scores in problem-solving during the pretest are at the beginning level. The total number of students is 68, 71, and 65 in problems 1, 2, and 3, respectively. However, the participants' scores in problem-solving in posttests improved, as shown in Figure 1, and their scores are distributed from the different levels of conceptual understanding. This implies that the student's level of conceptual understanding in terms of problem-solving is promoted from the beginning level to a higher level. Although some participants remained at the beginning level, it supports the quantitative results in Tables 1 and 2. As the results of DTG and NDTM approach in collaborative problem solving, participants greatly improved in answering problem solving. This improvement in students' conceptions may be from the involvement of small collaborative groups in problem scenarios (Bakaç & Taşoğlu, 2014), the use of guided questions (Budé et al., 2011) guided directions, and worksheets (Montero & Geducos, 2022).

The results from the quantitative data were reiterated by the qualitative findings in the responses of students about the implementation of DTG and NDTM in a collaborative problem solving analyzed using the thematic analysis and it improved their level of conceptual understanding. The students express in their answers in the focus group discussion that individual and collaborative problem solving activities during discussions help them understand the lesson. Student 8 explained that it was a good way to learn mathematical ideas because they could help their groupmates accomplish the activity by working together, helping each other, and sharing ideas in answering. While in individual activities, she tends to work independently and gather her ideas. Besides,

student 3 said that activities helped her so much; she could apply her learning in a fun way. She could also express her answers in so many ways. The collaborative activity sheets were also helpful because they could teach each other to improve their weaknesses. Similarly, with the work of Brhane and Abebe (2014), in interactive engagement, students were not retiring to express their feelings, there was a positive interdependence among students, and the classes were democratic. Moreover, it supports the work of Patalinghug & Arnado (2021) that teachers should develop their learners to be more independent in learning and encourage them to be active participants to trigger their creativity and uniqueness by opening up their unsolved questions and problems to their groupmates.

The basis of this study was the work of Budé et al. (2011) on the use of guided questions and Kirshner et al. (2010) on the comparison of guided and unguided instructions. When the participants were asked if they preferred having guided questions and directions during activities, most of their responses were yes, which helped them answer. Student 7 expressed that it was like a clue on what to do on that problem or question. While student 11 said that with guide questions, he would more likely get the correct answer. It reiterates that students learn best at their own pace when they are guided (Mahawan & Celedonio, 2023). Results of the quantitative study in Tables 6 and 7 reinforced this claim of students. The computed test statistics of groups under the DTG approach are a little higher than those in NDTM in the first and second phases of implementation. Therefore, it can be concluded that the students preferred having guided questions and directions, and it helped them. In preparing the activity sheets, the teachers may improve their questioning techniques as recommended by Dicdiquin et al. (2023) to promote more in-depth discussions, challenge students, and help students relate the lesson to the real world.

As uttered by the teacher-observer of this study, "It was evident in the presentation of the lesson that students were the ones who built the ideas of the lesson. This was successfully done by the teacher through the strategy she used. The teacher's appreciation of students' answers was felt since she said it exuberantly, leading you to imagine an all-smile teacher clapping her hands. The educational app she used was commendable. Indeed, it was a well-planned lesson." Furthermore, student 3 claimed that the teacher delivered the lessons in a very organized way. She likes how the teacher teaches consistently and uses different ways to apply the lesson to make her understand and remember the lesson more.

Overall, it can be deduced that DTG and NDTM in collaborative problem solving promote students' conceptual understanding, as proven by the statistical results and data analysis from problem-solving, and the two approaches were effective as it was supported by observers' and students' insights. According to National Council of Teachers of Mathematics (NCTM, 2010), 21st-century students must possess the conceptual understanding of mathematics to flourish and solve problems as adults in the presently changing environment. The use of the two approaches in teaching leads to an effective learning environment in helping students think critically, work collaboratively with others, and be creative.

Conclusion and Recommendation

Students' level of conceptual understanding had significantly improved after their exposure to DTG and NDTM in collaborative problem solving. As proof, the participants from the two groups are equally the same in terms of their understanding and knowledge about the topics before the implementation of the two approaches. Moreover, the participants obtained higher first posttest scores than the pretest scores. This indicates that both groups improved and increased their level of conceptual understanding and it implies the effectiveness of the two teaching approaches in promoting students' conceptual understanding during the first phase of implementation. In addition, the two groups sustained their high scores and level of conceptual understanding in their first posttest, which revealed that the treatment continues to show effect during the second phase of implementation. The participants performed better under the DTG approach than on NDTM teaching approach they preferred having guided questions and directions in

answering activities. Given the positive findings, Mathematics teachers should be encouraged to adopt and integrate the DTG and NDTM as teaching strategies to involve students and be independent learners, especially in problem-solving lessons. To ensure that learning is meaningful and to avoid wasting time reviewing, teachers must aim to teach and help the students acquire enough conceptual understanding during discussions. Moreover, the use of collaborative problem solving might be appropriate in different disciplines to help the students who have difficulty in problem solving. In order to test further the effectiveness of DTG and NDTM, future researchers might compare DTG or NDTM to a different teaching approach utilizing the switching replication treatment, or conduct a different topic to investigate or consider a longer span of implementation if it continues to show effect and might include the students' level of engagement.

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