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Relationship between Mathematics Teachers' Teaching Styles and Students' Achievement in Mathematics

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This study investigated the relationship between teaching styles of 30 grade 9 mathematics teachers and the achievement of their 1489 students. The Grasha Model of learning styles was adapted in the study. Results of the analysis indicated a significant relation between teaching style and student achievement based on students' highest mean percentage score. Approximately 39% of the total variance in students' achievement is attributable to the difference between the teaching styles. Post hoc comparisons showed that students whose teachers exhibit the Expert style, as well as those whose teachers use a combination of teaching styles have significantly higher achievement scores than students whose teachers employ the Formal Authority style of teaching. Since favorable teaching styles were identified from this study among grade 9 teachers and students, a wider research on the association of teaching styles and student achievement in mathematics focusing on other grade levels is being put forward. This may also help determine at which grade level student achievement starts to decline and further identify effective teaching styles appropriate for each grade level. Pre-service teacher training and in-service teacher retooling may likewise be conducted to leverage academic learning by allowing teachers to discover their teaching styles and improve on them.

Keywords: *teaching style, students' achievement, mathematics*

Introduction

Mathematics plays a vital role in one's daily life. Concepts and skills learned in mathematics allow one to think analytically and critically leading to informed decisions. In addition, everyday activities such as driving, cooking, playing games, project planning, and many others require specific mathematical understanding and application. As such, the Department of Education (2016) emphasizes the importance of using experiential and situated learning principles in its K to 12 Basic Education Curriculum for Mathematics. These learning principles allow Filipino learners to make sense of their direct everyday experiences where they can recognize the use and relevance of mathematics (Department of Education 2016).

However, studies on Filipino students' academic performance reveal that many students have an insufficient level of achievement in mathematics. In particular, the study of Capate and Lapinid (2015) on the performance and

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difficulties of students during the first year of implementation of the K to 12 Mathematics showed that students' level of achievement in Mathematics was still at the beginning to developing stages. Students were also found to have lacked critical problem-solving skills as they had not been re-checking their answers and had been incorrectly applying formulas, properties, theorems, or laws. The 2018 and 2019 National Achievement tests (NAT) attest to Filipino learners' deficient performance, especially in math (Malipot, 2019, Department of Education 2019b). Critical thinking skills registered the lowest mean in mathematics subjects.

Moreover, in their first attempt to join the Program for International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD) in 2018, Filipino students were found to be performing below Level 1 as defined by PISA's six proficiency levels (Department of Education 2016). As a result, the Philippines ranked least among the 79 participating countries in PISA 2018.

Level 1 in PISA's six proficiency levels is when students can answer basic concepts, carry out routine problems, and perform basic operations. This level is far from what is expected of them at Level 3 based on OECD average scores. Level 3 is when students can directly apply basic problem-solving strategies, interpret representations, and reason. In addition, the results of the 2018 PISA show that 19.7% of Filipino examinees attained proficiency levels 2 to 4. These levels indicate skills where students can employ basic algorithms, formulae, procedures, or conventions to solve problems involving whole numbers. Further, it is sad to note that only 0.01% of students performed within proficiency levels 5 to 6, where a learner is expected to develop and work with models for complex situations, identifying constraints and specifying assumptions.

Accordingly, with the similar result of the NAT and PISA reported, and although DepEd officials are already aware of what the result of the test will be, given the performance of students in NAT in the previous years, joining the PISA opened an opportunity for the education experts to assess where the Filipino learners currently are and go on with its call to quality education for all learners (Malipot 2019). Furthermore, this phenomenon calls for the need to find a way to make students learn mathematics to achieve better in the subject.

However, most of the literature focused only on student factors affecting achievement. Teacher factors affecting student achievement in mathematics may open another discussion that will help improve the quality of mathematics education in the country. For example, Liwag (2008) recommended observing different teaching strategies in mathematics classrooms, which may uncover more causes of poor mathematics reasoning abilities among students. In addition, Paz (2009), in his studies about teaching styles and students' performance, recommended that future researchers do more research on teaching styles in other fields, such as mathematics. Further, exploring teachers' role in the classroom instead of using research-based interventions is more recommended as these interventions are not fully implemented due to their complexity and inaccessibility, especially in regular public high schools.

Hence, looking into teacher factors that affect students' achievement may help the Department of Education's continuous call for quality education. For instance, research on teaching styles and mathematics instruction has established that teachers' mastery of content and teaching style positively influence students' mathematics performance. Furthermore, Caluya (2000) found a significant relationship between students' mathematics thinking and teachers' transformational practices in mathematics. Moreover, it was revealed that certain traits and practices of teachers influenced the students' demonstration of thinking skills. Sasing (2014), in her research on the influence and relationship between teacher's mathematical pedagogical knowledge (MPK), mathematical disposition (MD), and mathematics teaching experience of teachers on the mathematics performance and attitude toward mathematics of students, found that the MPK of teachers appears to influence both the mathematics performance and attitude of students. MPK is said to be how teachers relate their subject matter (what they know about what they teach) to their pedagogical knowledge (what they know about teaching) and how subject matter knowledge is a part of the process of pedagogical reasoning (Cochran et al. 1993 as cited in Turnuklu and Yesildere 2007). Sasing then recommends enhancing the MPK of teachers as this may impact student mathematics performance.

In addition, Davis-Langston (2012) mentioned that it is essential to look into teaching styles since there are still a few pieces of research on their quantitative impact on student achievement. In Langston's research on teaching style, teacher efficacy, and student achievement, there was a statistically low positive correlation among teaching styles contributing to mathematics achievement. Hence, interventions, teaching styles, or teacher efficacy may not be the only factors that can help raise students' achievement in mathematics.

In order to investigate the relationship between teaching style and the students' achievement in mathematics, this study specifically sought to answer the following questions:

1. What are the different teaching style profile of teachers?
2. What is the status of students' achievement in mathematics?
3. Is there an association between teaching style and students' achievement in mathematics?

Literature Review

The concept of "teaching styles" has been defined in various ways. Some refer to teaching styles based on the teacher's methods for classroom instruction. For instance, Peterson (1979) describes teaching styles in terms of how teachers use space in the classroom, their instructional activities and materials, and their method of grouping students. Similarly, McNeil and Wiles (1990) express teaching style as various ways in which teachers teach, and according to them, style is reflected in the teacher's attention and methods, such as verbal interaction, questioning, lecture organization, and the like. However, some studies refer to teaching styles based on teachers' behavior as they provide classroom instruction.

For example, Conti (1989) defines teaching style as the overall traits and qualities that a teacher displays in the classroom that are consistent for various situations.

On the other hand, Ornstein (1995) views teaching style as a broad dimension or personality type that encompasses the teacher's stance, the pattern of behavior, mode of performance, and attitude toward self and others. Ellis (1979), on the one hand, views teaching style as the set of models from which various teacher behaviors can be selected based on desired outcomes. Overall, teaching styles vary from teacher to teacher since they are heavily influenced by the teacher's personal qualities, philosophy in life, educational philosophy, and attitude (Beyond Crossroads 2006, as cited by Davis-Langston 2012).

Teaching Style Models

According to the literature, various teaching styles (Alias and Zakaria 2008, Davis-Langston 2012, Ornstein 1995, Paz 2009) are typically based on the critical roles and characteristics of the teachers inside and beyond their classrooms. Although teaching style, by definition, can refer to both methods and behaviors that teachers demonstrate inside the classroom, some studies devised several roles to describe further the teacher's interaction with the students and the teacher's view regarding the content. Some of these teaching style models are proposed by educators and writers as follows:

The model by Thelen et al. (1954) describes teaching styles similar to any one of the following scenarios: *Socratic,* where the teacher's image is a wise and thought-provoking teacher who argues with a student in purpose over a subject matter through artful questioning; *town-meeting,* where the teacher moderates the discussion until students arrive to answers by themselves; *apprenticeship,* where teachers serve as a role model in learning, decision making and life in general; *boss-employee,* teachers who use this style of teaching uses his/her authority and rewards or punishes the students for making sure that work is done; *good-old team,* a teacher in this style uses teamwork among students and plays as a coach in a team.

Meanwhile, Reissman and Silvert (1967) view teaching styles as based on the following: *Compulsive* is the teacher who teaches things over and over and is concerned with functional order and structure; *boomer* is the teacher who has a strong personality and motivates every student with a loud voice; *quiet,* the calm teacher that commands respect and attention; a *coach* is the informal athletic teacher that is physically expressive in the class; *maverick* is the teacher that raises difficult questions and presents disturbing ideas; *entertainer* the teacher who always has a joke and enjoys a laugh with the students; *secular* is the teacher who is relaxed and informal with students; and the *academic teacher* who always shares knowledge and substance of ideas.

Rubin (1971) on the other hand, enumerates the different styles of the teachers as any of the following: *explanatory,* where the teacher is in command of the subject matter; *informative,* where the teacher presents information and students are expected to listen and follow instructions; *interactive,* where the teacher facilitates the development of ideas; *programmatic* where the teacher guides student activities and facilitates independent learning; *inspiratory* where the teacher exhibits emotional involvement in teaching; and *corrective* where the teacher provides feedback by analyzing work, diagnosing for errors, and presenting corrective advice.

Meanwhile, Mosston and Ashworth (1985) argued that teachers could lead students to learn from basic to advanced information to creative problem-solving if they follow a universal and deliberate theory of teaching called the Spectrum of Teaching Styles (Mosston 1966) which investigated its application for some years. They have defined ten teaching styles that are categorized into two structures. The first half is called styles A to E. *Style A(command),* where the teacher decides, and students follow. *Style B (practice),* where students learn the initial decision-making steps because the teacher shifts specific decisions to them. *Style C(reciprocal),* where cooperative learning is practiced, and more decision-making is done by the students as they are given criteria to engage in observing, listening, comparing, contrasting, concluding, and communicating results to a fellow student. *Style D(self-check)* is when learners practice tasks designated by the teacher and evaluate themselves against established criteria. Finally, *Style E (inclusion)* is when each learner chooses options within a given task. The structure of styles A to E created conditions where students learn the basic skills about a subject matter. These involve engaging learners in cognitive skills such as memory recall, identifying, sorting, comparing, contrasting, and the like. Beyond that, the authors call the discovery threshold – an invisible line that divides the ten styles into two structures. The second structure contains styles that help students think more or beyond what is expected. These styles evoke the process of discovery and creativity, styles F-J: *Style F (guided discovery),* where teachers guide learners to unlocking concepts and principles; *Style G (divergent thinking),* where students discover alternatives through teachers' questions, problems or situations; *Style H(individual program learners design)* where a general subject matter is designated by the teacher and lets students discover the designs, questions and problems about it then seek solutions and verify them; *Style I (learner initiated)* this is when students can experience the skills learned from Style A to H, and they begin to initiate learning by making their own decisions but still in communication with their teacher to gain information; *Style J (self-teaching)* a style that happens outside the school where there is no need for a teacher because the learner makes all decisions.

Teaching Style by Grasha

Another established teaching styles model by Grasha (2002) looks at teaching style from the perspective of the following teaching approaches:

- Expert–The expert teacher possesses knowledge and expertise that students need, strives to maintain status as an expert among students by displaying detailed knowledge and challenging students to enhance their competence, and is concerned with transmitting information and ensuring that students are well prepared. The advantage of this style includes the teacher's ability to display information, knowledge, and skills; however, if overused, this can be intimidating to inexperienced students. In addition, the teacher may not always show the underlying thought processes that produce answers.

- Formal Authority–The teacher is concerned with the correct, acceptable, and standard ways to do things, provides positive and negative feedback, and establishes students' goals, expectations, and rules of conduct inside the classroom. The advantage of this style includes students' focus on clear expectations and acceptable ways of doing things. On the other hand, substantial investment in this style can lead to rigid, standardized ways of managing students and their concerns.
- Personal Model–The teacher oversees, guides, and directs by showing how to do things and encouraging students to observe and emulate the teacher's methods. The advantage of this style is that it is "hands-on," and it emphasizes direct observation of the teacher, and thus, the teacher becomes a role model. However, teachers who use this style may believe that their approach is the best way, and students may feel inadequate if they cannot live up to the expectations and standards set by the teacher.
- Facilitator–The teacher guides students by asking questions, exploring options, suggesting alternatives, and encouraging students to develop criteria to make informed choices. The overall goal is to develop independence and responsibility among students. This approach emphasizes the personal nature of teacher-student interactions. Its flexibility, focus on students' needs and goals, and willingness to explore options and alternative courses of action were the mentioned advantages of the facilitator style. However, this style is time-consuming and can be ineffective when a more direct approach is needed. The student's comfort will also be disadvantaged if the style is not done positively.
- Delegator–The teacher is concerned with developing students' capacity to function autonomously. This style contributes to students perceiving themselves as independent learners, but teachers may misread students' readiness for independent work, which is why some students may become anxious when given autonomy.

Grasha's teaching Style Clusters

Grasha's study established that all teachers possess each of the five styles to different degrees. Accordingly, he devised four clusters of the aforementioned styles in his continuous analysis of observations, interviews, and workshop experiences. Table 1 presents the clusters of teaching styles and the recommended activities.

Table 1. *Teaching Styles and Corresponding Activities*

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Primary Styles	Expert/formal authority	Expert/personal model/formal authority	Expert/facilitator/personal model	Expert/facilitator/delegator
Secondary Styles	Personal model/facilitator/ delegator	Facilitator/delegator	Formal authority/delegator	Formal authority/personal model
Activities	Lectures Term papers Guest presentations AVP Guest speakers Teacher–centered class discussions Strict standards/ requirements Grades/tests emphasized	Demonstrating ways of thinking/doing things Coaching/guiding students Illustrating alternatives Sharing personal viewpoints Sharing thought processes involved in obtaining answers Using personal examples to illustrate content points Having students emulate the teacher's example	Small group discussion Laboratory projects Instructor-designed group projects Student teacher of the day Self-discovery activities Learning pairs/debates Case studies Role plays/simulations Problem-based learning Practicum/guided readings	Student-designed group projects Independent study Independent research projects Position papers Student journals Modular instruction Self-discovery learning projects Cooperative learning activities

Note: Adapted from Grasha (2002, p. 158).

The combination of the high delegator and high expert teaching styles effectively develops conceptual problem-solving skills in chemistry (Paz 2009). Additionally, combining the high delegator and high facilitator teaching styles helps students achieve remarkable scores in conceptual problem-solving in chemistry (Paz 2009). Note that the combinations mentioned are in cluster 4 in Grasha's model.

Davis-Langston (2012) also conducted a related study to explore the relationships among teaching styles, teachers' perceptions of their self-efficacy, and students' mathematics achievement. Again, it was concluded that elementary school teachers' teaching styles and student mathematics achievement had a significant relationship.

The relationship showed that as teachers' perceptions of their use of these teaching styles increased, so did their students' achievement in numbers, operations, and mathematics. Moreover, Davis-Langston (2012) established that the statistically significant correlations found highlight the relationship between the teaching styles (personal model, facilitator, and delegator) and mathematics achievement; thus, clusters 2, 3, and 4 from Table 1. However, a negative correlation was found between the expert teaching style and students' mathematics achievement, which according to the author, harmfully influences student achievement.

Meanwhile, Dunn and Dunn (1978) argued that teaching style could be modified if the instructor understood how to respond to varied learning styles. For example, Hatfield et al. (1997) suggested that student-centered teaching styles be employed in teaching mathematics. It was further mentioned that manipulative materials, explorations, and discovery approaches would work well in teaching mathematics. As seen from Table 1, clusters 3 and 4 are such strategies mentioned. Concerning this, Liwag (2008) recommended that students' prevailing poor mathematics reasoning abilities should be the focus of classroom instruction, and the skills of making generalizations should be developed among students by augmenting exposure to this skill until mastery is done. Researchers should consider the causes of poor mathematics reasoning abilities through observation of the different teaching strategies in a classroom setting. Hence, teachers are encouraged to do curricular innovation that integrates the development of reasoning abilities through experiments.

Incidentally, Guloya (2007) mentioned that mathematics is one of the subjects least liked by students and that teachers must be well-trained in content and strategies. Liwag (2008) stressed that how teachers might develop their students' mathematics reasoning are the subject of many studies, such as the Third International Mathematics and Science Study (TIMSS). However, there has been little cooperative work on how math teachers structure lessons to develop reasoning in mathematics.

Students' Achievement in Mathematics

Based on their research, achievement in mathematics of American students was among the bottom 25 percent of all countries, reflecting a large extent of low teacher coverage of the subject matter. In our country, most research is usually based on interventions. Several studies have focused on developing students' mathematics reasoning, yet the status of mathematics achievement of Filipino students remains very low. Velasco (2013) even contended that for more than a decade, the mathematics thinking of Filipino students has not improved.

In the same way, in research about students' level of mathematical thinking concerning teachers' transformational practices in mathematics courses, Caluya (2000) found that even in relatively high-performing schools, both teachers and students find difficulty in proving theorems as well as solving problems that require complex solutions. Although progress was shown in the student's level of thinking from the original level they posted, only a few students displayed high-level skills. In addition, the progress was influenced by certain traits and practices of teachers like constant exposure to manipulative tasks, problem-solving activities and proving, prompt feedback of assessments, persuasiveness, time management, student-talk, teacher-facilitator scheme, and cooperative learning (Caluya 2000).

In similar research done by Escaran (2005) on investigating hypothetico-deductive reasoning using an inductive approach, although students had been exposed to the preliminaries of proof writing, they still lacked great readiness to deal with the deductive level of formal proof writing in mathematics. Hence, more time was needed for them to develop their proof-writing skills.

On the other hand, Guloya (2007), in her study on software-assisted instruction, students' thinking levels, and achievement in mathematics, found that the students' gain scores in the mathematics achievement test and levels of thinking were not statistically significant. Consequently, using software-assisted instruction does not necessarily improve students' achievement. Liwag (2008) likewise examined the mathematics thinking and reasoning abilities of 319 and 207 students from private and science high schools in Quezon City. It was found that the overall performance of students from both schools was at 50%, suggesting low thinking and reasoning abilities in mathematics. Meanwhile, Buendicho (2009) studied the effects of student-initiated questions on reasoning ability and mathematics achievement. It was reported that there was no significant between the student-initiated-questioning group and the teacher-posed-questioning group's mathematics achievement. Moreover, Solaiman et al. (2017) confirmed the findings of many researchers (Genz 2006, Tan and Yebron 2008, Dindyal and Besoondyal 2007) and found that not one of the 409 respondents reached the expected level of mathematics understanding of a student before entering the third year high school.

Furthermore, Lappan (1999) studied the data from TIMSS and the National Assessment of Education Progress (NAEP), showing that student performance in mathematics at all levels is quite alarming. Mistretta (2000) even established how students are not demonstrating strong conceptual knowledge of the subject. Incidentally, both old and current researches consistently show Filipino students' low performance in mathematics. Guloya (2007) also argued that mathematics is one of the least-liked subjects by students.

Methodology

This study investigated the relationship between teachers' teaching styles and student achievement. These objectives were achieved through a non-experimental quantitative method that utilized the correlational research design. Moreover, the study analyzed data gathered through researcher-made and adapted tests. The data gathered from the survey were used to find out (1) the teachers' teaching style and (2) the student's achievement.

In selecting the participants, multistage cluster sampling was performed. In this study, the stages involved selecting districts in the Division, followed by selection of schools, teachers, and students. The two districts in Division has twenty-one public secondary high schools, of which 15 are in Rodriguez and six are in San Mateo. From these 21 schools, only 13 schools were initially selected as these were accessible via public transportation. However, three schools declined, and thus these were excluded from the list. Therefore, 10 or 48% of the 21 schools comprised the sample. As can be seen in Table 2, seven schools (R1 to R7) were from Rodriguez District, and three schools (S1 to S3) were from San Mateo District. After selecting the schools, all the grade 9 mathematics teachers on the list were personally invited to participate in the study. The teachers were informed about the researcher's institutional affiliation and contact information, the purpose of the research, the confidentiality involved, and the instruments to be administered. The participation of the respondents in the study was voluntary. Teacher participants were also informed that they could decline at any time if they wished to. They were also informed that one of their grade 9 classes would be part of the study.

Table 2. *Demographic Profile of Participants*

School	No. of Teachers	Teachers' Gender		Teaching Experience (in years)				No. of Students
		Male	Female	1–5	6–10	11–15	16–20	
R1	1	0	1			1		51
R2	3	2	1		3			130
R3	3	1	2		3			151
R4	3	2	1	1			2	164
R5	3	1	2		3			167
R6	2	0	2			1	1	99
R7	6	2	4	4	1	1		293
S1	2	0	2		2			105
S2	3	1	2		3			136
S3	4	1	3		1	2	1	190
Total	30	10	20	5	16	5	4	1489

As shown in Table 2, a total of 30 mathematics teachers and one of their grade 9 classes comprised the participants of the study. Of these teachers, 21, or 70%, were from Rodriguez district while 9, or 30%, were from San Mateo; 20, or 66.7%, were female while 10, or 33.3%, were male, and 5, or 16.7% have been teaching for less than five years while 25 or 83.3% have been in the profession for more than five years. In all, a total of 1489 students participated in the study. They belonged to the respective grade 9 classes of the 30 teacher-participants. Each class had an average size of 49 students.

Instruments

<u>Teaching Style Inventory</u>

The Teaching Style Inventory Version 3.0 by Grasha (1996) was adapted for use in identifying teachers' teaching styles in this study. It is an open-access instrument tagged by Dr. Carrie Myers, the program leader for the College Teaching Certificate of the Graduate School of Montana State University in Montana, the US, where Grasha was once affiliated. The instrument is a 40-item test that employed a Likert-style response format, with options ranging from 1 (strongly disagree), 2 (disagree), 3 (somewhat disagree), 4 (neither agree nor disagree), 5 (somewhat agree), 6 (agree), and 7 (strongly agree) for responses. The questions are designed to categorize the various teaching styles, namely, (a) expert, (b) formal authority, (c) personal model, (d) facilitator, and (e) delegator.

The test was revised to suit the styles and situations of a mathematics teacher. Three experts, one in the field of psychology, one in mathematics, and one in educational research, validated the content and structure of the instrument. Revisions were made based on the comments and suggestions of the experts until the instrument was ready for pilot testing. After the pilot testing of the revised instrument, the scale reliability was measured using Cronbach's alpha to test the internal consistency of the items. Results showed a reliability coefficient of 0.803, suggesting a high internal consistency.

Responses were then scored according to Grasha's scoring key. Finally, mean scores were computed according to the dimensions (expert, formal authority, personal model, facilitator, and delegator) as shown in Table 3.

Table 3. *Teaching Styles*

Teaching Style/Norm	Low	Moderate	High
Expert	1.0–3.2	3.3–4.8	4.9–7.0
Formal Authority	1.0–4.0	4.1–5.4	5.5–7.0
Personal Model	1.0–4.3	4.4–5.7	5.8–7.0
Facilitator	1.0–3.7	3.8–5.3	5.4–7.0
Delegator	1.0–2.6	2.7–4.2	4.3–7.0

Note: Adapted from Grasha (1996).

Achievement Test

An achievement test was created based on Grade 9 third-quarter competencies in the mathematics curriculum. The topics included in the test were quadrilaterals, triangle similarity, and Pythagorean Theorem. The achievement test was composed of 35 multiple-choice items validated by a panel of content experts in mathematics. The test was pilot tested to 30 students. Using the KR-20 test, a reliability coefficient of 0.77 was obtained, clearly suggesting an acceptable and good internal consistency of the test items.

Results and Discussion

The Teachers' Teaching Styles

Discussion of the results related to teaching style profiles of the teacher-participants is based on the (a) mean score of teaching styles; (b) degree to which they manifest each teaching style; (c) teaching style with the highest mean score; and (d) frequency of teacher-participants per cluster of teaching style.

Table 4. *Teaching Style based on Mean*

Teaching Styles	$\bar{x}$	SD	Descriptive Value	Norm (High)
Expert	5.99	0.38	High	4.9-7.0
Formal Authority	5.85	0.42	High	5.5-7.0
Personal Model	5.77	0.41	Moderate	5.8-7.0
Facilitator	5.63	0.53	High	5.4-7.0
Delegator	5.78	0.44	High	4.3-7.0

Table 4 shows the mean score of all teachers in a particular teaching style. Descriptive information shows that the highest mean and descriptive value is "expert" at 5.99, with a descriptive value of high. Additionally, "formal authority" has a mean score of 5.85 (high), "delegator" has a mean score of 5.78 (high), and "facilitator" at 5.63 (high). On the other hand, only the "personal model," whose mean is 5.77, has a descriptive value of moderate.

The "expert" style represents a teacher who transmits knowledge to students (Grasha 2002). In this style, all information regarding the subject would come from the teacher. Canto-Herrera and Salazar-Carballo (2010), in their research about the relationship of teachers' beliefs and teaching style to student achievement in mathematics, found the same result, where the "expert" teaching style had the highest mean. The same result was found by Magulod Jr. (2017) in Cagayan among pre-service mathematics teachers. All these results confirm Grasha's claim that teachers in mathematics usually apply the "expert" teaching style.

It is also good to note that "expert" and "formal authority" teaching styles are popular in situations where the class size is large, there is a timetable for covering a topic or material, and teachers have to prepare their students for standardized exams (Grasha 2002). As observed during the data gathering, these are the usual teaching scenarios in the Philippine education system: large class size, with some class sizes ranging from 40-60 students, 49 on average in this study, and time table covering the topic. Moreover, the administration of the achievement test was moved toward the latter part of the study as requested by the teachers because, according to them, the lessons covered by the test were not yet discussed in some classes. Therefore, the styles "expert" and "formal authority" were among the teaching styles with the highest mean because it is the most convenient in this situation. However, when these styles are followed, knowledge retention may be short (Grasha 2002).

On the other hand, Grasha's (2002) conceptual model of teaching style further established that all teachers possessed each of the five styles in varying degrees. This study looked into the different degrees to which teachers manifest the five styles (see Table 5). Based on the results, it can be inferred that in terms of teaching style degree, a majority (70% or more) of the teachers scored high in all categories, except for "personal model," where there are only 13 or 43.3% who scored high and 17 or 56% who scored moderately. Moreover, the 13 teachers who scored high in the "personal model" gave the highest mean rating (6.14) among all categories.

Table 5. *Teaching Style Based on Degree*

Categories	Degree	f	%	$\bar{x}$	SD
Expert					
	High	30	100	5.99	0.38
Formal Authority					
	High	25	83.3	5.98	0.35
	Moderate	5	26.7	5.25	0.13
Personal Model					
	High	13	43.3	6.14	0.23
	Moderate	17	56.7	5.48	0.23
Facilitator					
	High	21	70	5.88	0.34
	Moderate	9	30	5.04	0.41
Delegator					
	High	30	100	5.78	0.44

Accordingly, from Table 5, the "personal model" is the style with the lowest descriptive value (moderate). "Personal model" is said to be the teaching style where the teacher becomes a person to emulate by the students, and according to Grasha (2002), this style is often used in theatre arts. A contradicting result was found by Atasoy et al. (2018) about the relationship between mathematics teachers' instructional styles and educational philosophical background, where the "personal model" was perceived to be the highest teaching style preferred by the participants. These researchers from Turkey believed that the confidence of teachers in this style (personal model) is complete.

In addition, the teachers' teaching style profile in this study was determined based on the highest mean score in the five teaching style categories. Results (see Table 6) indicated that while the majority (76.7%) of the teachers manifest a single teaching style, some (23.3%) teachers scored highest in more than one or a combination of teaching styles. It is also interesting to mention that the results (based on Tables 5 and 6) confirm Grasha's conceptual model of teaching style that a teacher may possess more than one teaching style in varying degrees.

Table 6. *Teaching Styles Based on Highest Mean Score*

Teaching Styles	***f***	**%**
Expert	12	40.0
Formal Authority	5	16.7
Personal Model	1	3.3
Facilitator	1	3.3
Delegator	4	13.3
Total	23	76.7
Expert, Delegator	2	6.7
Expert, Formal Authority	1	3.3
Expert, Formal Authority, Personal Model	3	10.0
Expert, Facilitator, Delegator	1	3.3
Total	7	23.3
Grand Total	30	100.0

Recall that Grasha's continuous analysis of teachers' observations, interviews, and workshop experiences gave rise to four clusters of the aforementioned teaching styles. Thus, the teachers in this study were further classified according to the same clusters Grasha (2002) described based on their primary teaching style or teaching style/s rated with the highest degree. However, as shown in Table 7, results indicate that while some teachers have been classified according to the clusters defined by Grasha (2002), the others were not assigned to any of the four clusters.

Table 7. *Teaching Styles based on Clusters*

Cluster and Teaching Style	*f*	%
Cluster 1 Primary Style: Expert and Formal Authority	4	13.4
Cluster 2 Primary Style: Expert, Personal Model, Formal Authority	7	23.3
Cluster 3 Primary Style: Expert, Facilitator, Personal	0	0
Cluster 4 Primary Style: Expert, Facilitator, Delegator	9	30.0
Cluster 5 Primary Style: Formal Authority, Personal Model, Delegator	1	3.3
Cluster 6 Primary Style: Expert, Formal Authority, Delegator	3	10.0
Cluster 7 Primary Style: Expert, Delegator	6	20.0
Total	30	100.0

There are 4, or 13.4%, teachers who fall under cluster 1 (expert, formal authority); 7, or 23.3%, fall under cluster 2 (expert, personal model, formal authority); none, or 0%, fall under cluster 3 (expert, facilitator, personal model), and 9 or 30% fall under cluster 4 (expert, facilitator, delegator). Two-thirds of the teachers, 20 or 66.67%, fall under the four clusters; surprisingly, 10, or 33.33%, are not in any of the clusters. It means that their primary teaching styles are not any of the 4 clusters defined by Grasha. This result contradicts Grasha's (2002) study, where 92% of them fit in the four clusters. Hence, this study tried to determine their primary styles and came up with clusters 5, 6, and 7. From Table 7, 1 or 3.3% fall under cluster 5 (formal authority, personal model, delegator), 3 or 10% fall under cluster 6 (expert, formal authority, delegator), and 6 or 20% fall under cluster 7 (expert, delegator).

From Grasha's interpretation, clusters 5 to7 are a combination of student-centered and teacher-centered styles. Incidentally, some studies using Grasha's model have found an effective combination of teaching styles, although they were not in any of the four clusters. For instance, in local research about teaching styles and student performance in conceptual and algorithmic problem-solving in chemistry, Paz (2009) found that the combination of the high delegator and high expert teaching styles is effective in the development of conceptual problem-solving skills and helps in achieving a remarkable score in both conceptual and algorithmic problem-solving in chemistry. On the other hand, teachers with expert and delegator teaching styles do not fall in any of Grasha's clusters (see Table 7).

In addition, Davis-Langston (2012), in his research about the relationship among teaching style, teachers' perceptions and teachers' self-efficacy, and students' mathematics achievement, found a significant positive correlation in two other clusters (personal model, facilitator, delegator; formal authority, facilitator) not in any of the clusters in Grasha's model. Note that the four clusters of styles were obtained from a systematic study based on analysis of classroom observations and interviews with teachers and the responses of several hundred workshop participants who related the five styles to the instructional processes they employed in the classroom (Grasha 2002). However, in this study, the new clusters may also give rise to a combination of teaching styles that may help student achievement in the Philippine setting. Moreover, the researcher listed possible activities a teacher may do in the new clusters discovered in this study using Grasha's teaching styles and related activities on Table 8.

From another angle, it can be observed based on the suggested activities that clusters 3 and 4 suggest student-centered teaching styles. In addition, Hatfield (1997) argued that student-centered teaching styles like those in either clusters 3 and 4 work well in teaching mathematics. In addition, the suggested activities by Grasha (2002) answer the stipulated learning principles and theories in the framework of the mathematics education system by Department of Education (2016). These learning principles, discovery and inquiry-based learning, experiential and situated learning, reflective learning, constructivist learning, and cooperative learning, guide mathematics teachers and enable their learners to achieve mathematics education's twin goals: critical thinking and problem-solving.

Table 8. *New Clusters of Teaching Styles and Corresponding Activities*

	Cluster 5	**Cluster 6**	**Cluster 7**
Primary Styles	Formal Authority, Personal Model, Delegator	Expert, Formal Authority, Delegator	Expert, Delegator
Activities	Demonstrating ways of thinking/doing things Independent study Using personal examples to illustrate content points Having students emulate the teacher's example Teacher–centered class discussions Strict standards/requirements Grades/tests emphasized	Lectures Teacher–centered class discussions Strict standards/requirements Grades/tests emphasized Self-discovery learning projects Cooperative learning activities	Lectures Term papers Teacher–centered class discussions Small group discussion Laboratory projects Student teacher of the day Self-discovery activities Case studies Role plays/simulations

Note: Adapted from Grasha (2002, p. 158).

Student Achievement

The achievement test was administered to the student participants from one of the intact classes handled by each of the teacher participants. The classification of mastery level is based on the quartile distribution of mean percentage scores (MPS) among schools by Department of Education (2019), in which the national standard level of acceptable MPS for all subject areas is 75%.

Table 9. *Students' Mastery Level in Achievement Test*

	Per Student		**Per Class**	
Level	*f*	%	*f*	%
Superior (76–100%)	9	0.60	0	0
Average Mastery (51–75%)	242	16.26	2	6.67
Low Mastery (26–50%)	678	45.53	26	86.66
Poor (0–25%)	560	37.61	2	6.67
Total	1489	100.0	30	100.0

Note: Students' raw scores and class mean percentage scores are used to determine the frequency in each quartile.

As can be seen in Table 9, based on individual raw scores, results indicate that only nine students or 0.6% can reach the superior level of mastery. 242, or 16.26%, are at the average level, 678, or 45.53%, are at a low level, and 560, or 37.61%, are at a poor level. Most 1238 or 83.14% student participants fall below the 75%-acceptable level. Accordingly, based on class mean percentage scores (MPS), none of the intact classes are at a superior level. Only 2, or 6.67%, fall under the average level, 26, or 86.66%, under the low level, and 2, or 6.67%, under the poor level of mastery. Remarkably, not even 1% of the intact classes can reach the superior level of mastery. When grouped per class, 28, or 93.33%, of the classes are below the acceptable level, while only 2, or 6.67%, are at the average mastery level.

The results shown in Table 9 confirm the reports of several studies (Buendicho 2009, Caluya 2000, Escaran 2005, Guloya 2007, Liwag 2008, Solaiman 2013, Velasco 2013), which emphasized that only a few numbers of students achieved the mastery level in mathematics. This result has been the scenario for decades and needs so much attention.

In particular, the importance of teaching and learning mathematics was established at the beginning of this paper, especially since it plays a vital role in the field of mathematics and life in general. Several local studies mentioned similar thoughts on the importance of developing students' mathematical skills because it contributes to their critical thinking and problem-solving (Buendicho 2009, Liwag 2008, Solaiman et al. 2017). Upon confirming results on students' achievement in the last decades to be below mastery level, it is suggested by this study to look into some teacher factors related to students' achievement in mathematics since it was established that teachers' mathematics competencies are critical to the effective teaching of the subject (Ndlovu 2014).

Teachers' Teaching Style and Students' Achievement in Mathematics

This section examines the relationship between teachers' teaching styles based on Grasha's model and students' achievement in mathematics. Two teaching style profiles were used to analyze the data: (1) based on clusters, as described in Table 7, and (2) based on the highest mean, as described in Table 6. Prior to the test of association, a one-way analysis of variance was used to examine whether the students' achievement is a function of teaching style.

For the first set of analyses in this section, the researcher utilized the data on the respondents' primary teaching style or teaching style/s rated with the highest degree to determine the teachers' corresponding cluster. The categories of teaching style were: (1) cluster 1 (expert, formal authority); (2) cluster 2 (expert, personal model, formal authority); (3) cluster 4 (expert, facilitator, and delegator); and (4) cluster 0 (those who did not fall in any of the four clusters). Still, the dependent variable was the students' MPS on the researcher-made achievement test.

It was made sure that the assumptions for independence, normality, and homogeneity of variance were met before the one-way ANOVA was generated. The results of the one-way ANOVA indicate no significant difference (3, 26)= 1.120, $p<0.359$ at a 0.05 level of significance (see Table 10). This result shows no significant differences in students' achievement test scores among the clusters of teaching styles. This result may mean that student achievement is the same regardless of teachers' teaching styles.

Table 10. *ANOVA of Teaching Styles and Students' Achievement in Mathematics*

	Sum of Squares	***df***	**Mean Square**	***F***	***p***
Between Groups	43.62	3	14.54	1.120	0.359
Within Groups	337.30	26	12.97		
Total	380.92	29			

*p<0.05.

That being the case, this result failed to accept the research hypothesis that there is a significant relationship between teachers' teaching styles and students' mathematics achievement. Furthermore, this result contradicts that of Paz (2009), that student-centered teaching styles (clusters 3 and 4) help students achieve a remarkable score in conceptual problem-solving. In addition, the result is also contrary to what Langston (2012) concluded in his study, that positive correlations exist among the three teaching styles found in clusters 3 and 4 of Grasha's conceptual model of teaching style and student achievement.

Still, Goodman and Kruskal's gamma was run to determine the association between teaching style based on the clusters and students' achievement (see Table 11). Results indicate no correlation between the two variables ($G=0.083$, $p<0.622$). This result means that teacher's teaching style is not associated with student achievement in mathematics, leading to the rejection of the research hypothesis.

Table 11. *Correlation of Teaching Style and Students' Achievement*

	Value	**Asymp. Std. Error**	**Approx. T**	***p***
Gamma	0.083	0.167	0.494	0.622
N of Valid Cases	30			

*p<0.05.

The results from the previous section prompted the researcher to do another analysis to test the association between teachers' teaching style and students' achievement using the teaching style profile based on the highest mean score (see Table 6). This time, the teachers were grouped according to the teaching style where they scored the highest, and if the teachers scored highest in more than one teaching style, they were classified under the combination category. For this profile, the categories of teaching style were (1) expert, (2) formal authority, (3) personal model, (4) facilitator, (5) delegator, and (6) combination. The dependent variable was the students' MPS on the researcher-made achievement test, the same as the data used in the first section.

Although assumptions for independence and normality were met, the result of Levene's test for homogeneity of variance shows a significant difference between the variances of the teaching style and student achievement at $F(3, 24)=3.77$, $p>0.024$. This result means that the assumption for homogeneity of variance was not met. Newsom (2020) explained that when the assumption for homogeneity of variance is not met, and there are unequal group sizes, Welch's test is an alternative test for ANOVA. Newsom (2020) cited Welch (1951) that it is good to consider Welch's test in cases when sample size and variance are not equal. Hence, for this particular data, Welch's robust test results indicate a significant effect, Welch's F (3, 9.39)=7.071, p<0.009 at a 0.05 level of significance. This result shows significant differences in students' achievement test scores among the teaching styles according to the highest mean. This result means that student achievement is a function of teachers' teaching styles. The estimated omega squared (ω^2=0.39) indicates that approximately 39% of the total variance in students' achievement is attributable to the difference between the teaching styles based on the highest mean scores.

Table 12. *Post Hoc Results for Students' Achievement by Teaching Styles Based on Highest Mean Score*

		Mean Differences ($\bar{X}_1 - \bar{X}_2$) (*p* value and effect sizes are indicated in parentheses)			
Teaching Style	Mean	Expert	Formal Authority	Delegator	Combination
Expert	41.96				
Formal Authority	29.55	12.41 (*p* = .011)* (1.59)			9.80 (*p* = .036)* (1.86)
Delegator	45.16				
Combination	39.55				

*p<0.05.

Post hoc comparisons using Games-Howell test procedures were likewise used to determine which pairs of the four group means differ significantly. The results shown in Table 12 indicate that students whose teachers have a high mean score on expert style (M=41.96, SD=10.71) have a significantly higher achievement score than students whose teachers have a high mean score on formal authority (M=29.55, SD=2.80) style of teaching. The effect size is 1.59, and the result is statistically significant at p=0.011. Additionally, those students whose teachers have a high mean score on a combination of teaching styles (M=39.35, SD=6.9) have significantly high average MPS scores than those students whose teachers have a high mean score on formal authority (M=29.55, SD=2.80) style of teaching. This result is also statistically significant at p = 0.036 with an effect size of 1.86.

However, when Goodman and Kruskal's gamma was run to determine the association between teaching style (highest observed mean) and students' achievement (MPS), it was found that there is no correlation between the two variables (G=-0.047, p<0.778) (see Table 13).

Table 13. *Correlation of Teaching Styles Based on Highest Mean Score and Students' Achievement*

	Value	**Asymp. Std. Error**	**Approx. T**	***p***
Gamma	-0.047	0.169	-0.282	0.778
N of Valid Cases	28			

**p<0 .05.*

Not statistically significant results suggest looking into other factors such as the teachers' awareness of how students learn best, continuous training, developing the reasoning ability of students, and even looking into the affective factors as it can lead to new reasons that may explain the poor mathematics reasoning abilities of Filipino students (Guloya 2007, Liwag 2008, Solaiman et al. 2017, Ndlovu 2014). Moreover, these results confirm that other teacher factors may be related to student achievement (Mahmud and Salimian 2012, as cited in Kušen and Marinović 2013).

Grasha (2002) did address not only teaching styles but also studied the different learning styles of students. According to him, looking into the different learning styles does not mean that what teachers do in the classroom is not significant; however, there is a need to integrate both teaching and learning styles to see success in student achievement further. Thus, teachers may also consider students' different learning styles to apply the most suitable teaching styles for students.

Conclusions and Recommendations

This study has found that although teachers have high scores in effective teaching styles such as expert, facilitator, and delegator, student mathematics achievement remains below the mastery level. It is noted that not even one percent can reach the superior level. Additionally, although there is no significant relationship between teachers' teaching styles when grouped according to clusters and students' achievement in mathematics, a significant relationship was found between teachers' teaching styles when grouped according to the highest mean score and student achievement in mathematics.

In this regard, other teaching styles, especially in the post-pandemic period aside from Grasha's model, may be investigated to find other ways to improve student achievement. Apart from this, other factors may be looked into in future research, such as limited time of lectures, class size, learning environment, study habits, and the usual disruption of classes due to valid reasons such as typhoons, calamities, and epidemic disease and viruses to improve student achievement in mathematics.

Future researchers may increase the samples and expand the population to include not only one cluster in the division. Alternatively, another study may focus on other content areas and grade levels as this will give a different viewpoint of teaching styles and help determine which grade level the student achievement started to decline since this study is limited to grade 9 lessons only.

On the part of the administration, the Department of Education may ensure maximizing academic learning time by training pre-service teachers and re-tooling in-service teachers to develop teaching styles that will leverage student learning in mathematics.

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