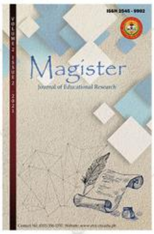

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A Constructivist Approach in Teaching Polynomial Functions and Segments of Circle in Junior High School

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Abstract

The study evaluated the effectiveness of the constructivist approach in teaching polynomial function and segments of circles on the academic achievement of Junior High School Students in a Public School in the Northern Province of Cebu. The quasi-experimental research design was used. Two sections were conveniently selected with 87 Grade 10 student participants. A modified, adapted questionnaire was used as the instrument to measure the academic achievement of the students. Data were treated using a t-test of sample groups. The study showed a significant difference in pre-test and post-test achievement in both groups ($p<0.05$); however, upon comparing the achievement of the two groups in their post-test, results showed no significant difference ($p>0.05$). Both approaches show the same impact on students' academic achievement in Mathematics. However, using the constructivist approach shows that students had a higher mean with slightly consistent performance than direct instruction. The findings demonstrated that the constructivist approach could be used in a Mathematics classroom, which shows a favorable effect on the development of lesson engagement and enhances students' achievement. Additionally, this approach develops active involvement with the lesson and their critical-thinking skills.

Keywords: *Constructivism, 5E model, academic achievement, mathematics, quasi-experimental research design*

1. Introduction

The constructivist approach is a contemporary trend in teaching and learning. It anchors the belief that *"every individual constructs their knowledge and understanding through reflecting on the individual's experiences."* Students do not discover how the world works; instead, they invent new ways of thinking about the world where the child's knowledge is actively created or developed, not passively received from the environment (Battista, 1990). It is considered student-centered education, where students play an essential role in constructing meaning from their experience (Prince et al., 2006). The role of the teacher shifted from the giver to the facilitator of the learning. The idea of education emphasized knowledge as a product to knowing as a process (Jones & Laura., 2001). Many researchers agree that using Constructivism can improve students' performance (Hendry et al., 1999; Ertmer & Newby., 2008: Ayaz & Sekerci, 2015; Barman & Bhattacharyya, 2015; Samaresh, 2017). According to Gunduz and Hursen (2015), it is gaining attraction in different fields, especially in the subjects like Science and English. The approach was introduced in the Mathematics subject during the K to 12 curricula implementation in 2012-2013. Constructivism was one of the learning theories that supported the framework of the K to 12 Mathematics curriculum (Curriculum Guide, 2012). Constructivism in mathematics education is relative to teaching style, development of curriculum about problem-solving, and differences in understanding from cognitive psychology (Lerman, 1989). According to Bodner (1986), logico-mathematical knowledge cannot be directly transferred from the teacher's mind to its students; it requires the student, who is the constructor of knowledge. This shifts the role of the teachers not as a dispenser of knowledge but as a guide in the organization of concepts in the areas of experience (Von Glasersfeld, 2012). A learner's mathematical reality must be taken inconsiderately in their performance (Thompson, 2020).

However, it has been observed by the researcher that direct instruction, the traditional approach, is still widely practiced inside a mathematics classroom. In the study of Portrait of Filipino Teachers' Classroom, the researcher contends that the teacher's pedagogical practice is still verging towards the formal suggested as a traditional inclination (de Mesa & de Guzman, 2006), and teachers find it challenging to promote learner-centered approaches (Verzosa & Vistro, 2019). Some researchers point out the role and effects of direct instruction in the classroom (Adams & Engelmann,1996; Magliaro et al., 2005). Teaching mathematics should consider the subject's abstract and hierarchical nature (Skemp, 2012). The research summary review of direct instruction by Przychodzin et al. (2004) shows that direct instruction has positive results for math programs. The same study showed that Math programs effectively meet national Council of Teachers of Mathematics (NCTM) principles) using the DI. However, the study of Dean and Kuhn (2007) contends that DI was not enough to sustain learning over time; it is not how fast the understanding can be acquired but how well it can be acquired. Knowledge is subjective, and each student creates a distinct mathematical reality based on their experiences with circumstances and cognitive frameworks (Park & Shin, 2021).

The Trends in International Math and Sciences Study (TIMSS, 2007) results show that the Philippines performed low compared to other countries in Mathematics and Science. This case challenges math educators on alternative teaching approaches that aim for a positive result in these fields. The teachers should be re-socialized in their new roles in the teaching-learning process in the changing times. While the studies of constructivist theory give a promising result, the present study evaluates the effectiveness of Constructivism in teaching mathematics compared to direct instruction at the junior high school level as an alternative teaching approach in Mathematics Education. The current study seeks to verify the approach in teaching polynomial functions, their graphs, application, and teaching the parts of circles to junior high school students.

2. Methodology

The quasi-experimental research design was used to determine the effectiveness of the constructivism approach in teaching mathematics. Quasi-experimental is a prospective or retrospective study in which different groups have different treatments to compare the effectiveness of this treatment (Maciejewski, 2018). This is to see the cause-and-effect relationship without randomizing the participants. Research participants were selected through convenience sampling from the available pool of students whom the researcher was the Mathematics teacher. There were two sections selected with a total of 87 Grade 10 students. The first section was composed of 44 students in the control group taught using direct instruction, the traditional method. The second section was composed of 43 experimental group students taught using the constructivist approach. Permission to conduct the study was requested and approved by the Public Schools Division Superintendent of the Cebu Province and the secondary school principal.

The research instrument used was an adapted second periodic examination questionnaire. The questionnaire was patterned from the DepEd textbook with modifications by the Grade 10 Mathematics teachers, including the researcher, and was tested through pilot testing. Consent was requested from the school principal, the Mathematics Department Head, and the Grade 10 coordinator for the exam use. The tool was used to measure the academic achievement of both groups. The participants answered the pre-test before the start of the study to get the baseline data. After the intervention, the same participants answered the post-test to identify a significant difference between the two methods. Further, randomly selected students had informal interviews that focused on their learning experiences within the quarter. The T-Test for the dependent and independent sample groups was the analytical tool to assess the significant difference between the scores at a 0.05 significance level. It was hypothesized (H_0) that there was no significant difference between the two approaches.

The 5E instructional plan and the Direct instruction plan were utilized in teaching the students on second-quarter topics, namely: polynomial functions, graphing of polynomial functions by the table of values, leading coefficient test, end behavior & multiplicity, parts of circles, central angles and arcs, secants and tangent of the circles. The number of hours, objectives, topic covered, and description of using the constructivism approach in delivering the lesson is presented on Table 1.

There was a four-day meeting of the students in a week, so each lesson was taught in a minimum of one week. The same lesson was also taught to the other group using the direct instruction method. The activities in this class were primarily lectured base and chalk talk. The students listened to the discussion with minimal student activity.

3. Results and Discussions

Table 2 shows the *t*-Test analysis of the significant difference in the academic achievement of the control and experimental groups.

The result shows the pre-test achievement of the students in the two groups. The pre-test exam consisted of 48 multiple-choice questions. The computed t-value (t=0.735) was less than the critical value (1.988). Hence, there was no significant difference between the pre-test achievement of the two groups. It implies that both groups have similar entry levels of knowledge, and both are at the same level in their

Table 1. Lesson Coverage

Session (No. of hours)	Goals and Objectives Based on the K-12 Curriculum Guide (Knowledge, Skill, Attitude (KSA))	Topics Covered	Description
3 hours	**K:** Describe and evaluate polynomial functions. **S:** Convert the standard form of a polynomial function to factored form. **S:** Illustrates a polynomial function. **A:** Works patiently in illustrating a polynomial function.	Polynomial functions	The topic focuses on polynomial functions. A series of activities led to the conversion and illustration of a polynomial function. Activities were done through collaborative work.
4 hours	**K:** Determines the x-intercept, y-intercept, and roots/zeroes of the function. **S:** Graphs polynomial function using zeroes and table of signs. **A:** Shows patience in locating the intercepts and graphs of function in a cartesian coordinate plane.	Graphing of polynomial functions	The teacher used images of a graph of the different functions, and the student discussed with their partners the difference between these graphs. The students then worked together to answer a task that determined the intercepts and roots of the function. Then another activity was given to connect the relationship of the roots to the graph of functions using the table of signs.
5 hours	**K:** Find the zeros (x-intercepts) of a polynomial function and its multiplicity of it. **S:** Graph the polynomial functions using the Leading Coefficient **S:** Test to find the end behavior of the graph and **S:** Find the multiplicity of zero and know if the graph crosses the x-axis at the zero or touches the x-axis and turns around at the zero **A:** Shows cooperation and teamwork in graphing the polynomial function.	Graphing Polynomial Function using Leading Coefficient Test, End Behavior & Multiplicity	The lesson started with a group activity where a card was flashed with a polynomial function, and the students determined the function's leading term, leading coefficient, and leading degree. Then, they answered a guided activity to understand end behavior and multiplicity. It was then reinforced with a Train Station Group Activity where they discussed concepts with their members based on the different stations.
3 hours	**K:** Derives the relations among chords, arcs, central angles, and inscribed angles inductively. **S:** Illustrate chords, arcs, central angles, and inscribed angles. **A:** Work cohesively in a team.	Parts of circles	The class started with observing the circular structures in the surrounding, then followed by exploring and drawing the different parts of the circle using the definitions. The student also played a "Paint me a Picture" game to illustrate the chords, arcs, and angles. They also answered activities to reinforce the concept.
3 hours	**K:** Illustrates the sector and segments of a circle. **S:** Solves the measurement of the area and sector segment. **A:** Shows patience in solving sectors and segments.	Central Angles and Arcs	A pizza was used to present a circle, and each slice was the sector of a circle. They answered the think-pair-share task on the measures of the area and segments, followed by a group board work activity.
4 hours	**K:** Illustrates the secants and tangents of a circle. **S:** Apply the theorems in secants and tangents in solving the measurement of angles and arcs of a circle. **A:** Participates during class discussions.	Secants and Tangents of a Circle	The student played Paint me a picture to illustrate the secant and tangent line of a circle. This is followed by an activity using strings, adhesive tape, and an illustration board to differentiate the two lines. Students also answered practice exercises in solving the secant and tangents of a circle.

academic achievement. Thus, the researcher proposes to use the constructivist method to test its effectiveness against the direct approach as another teaching method to improve the student's academic achievement. According to Samaresh (2017), the constructivist approach strategy can help students become more adept at understanding content at higher levels of cognition. It has its roots in Vygotsky's theory, which holds that learners generate knowledge in their minds rather than having it transmitted to them from teachers. A result study from Suhendi et al. (2021) demonstrates that Constructivism is a promising approach and has a favorable effect on education restructuring as it can enhance students' abilities. Teachers will go beyond merely imparting knowledge to students and begin concentrating on developing lessons that encourage learners to use critical thinking and problem-solving approaches (Hinduja, 2021). The current study seeks to utilize the method to increase the student's achievement in the subject.

Table 2. t-Test Analysis of the Significant Difference in the Pretest Achievement

Groups	n	Pre-test	SD	Computed Critical T-Value	Critical T-Value	Decision
Direct Instruction	44	13.75	3.21	0.735	1.988	Fail to reject H_0
Constructivist Approach	43	14.28	3.49			

Table 3 shows the *t*-Test analysis of the two groups' academic achievement of the pre-test and post-test achievement using the t-test of a dependent sample.

Table 3. t-Test Analysis on the Difference of the Means of the Pre-test and Post-test Achievement

Groups	n	Pre-test Mean	Post-test Mean	P-value	Decision
Direct Instruction	44	13.75	30.34	0.000	Reject H_0
Constructivist Approach	43	14.28	32.65	0.000	Reject H_0

Since the p-value is 0.000 in the direct instruction group, which is less than 0.05, the researcher rejects the null hypothesis. Therefore, there is a significant difference in the pre-test and post-test scores in the direct instruction group. The direct instructional model improved the academic achievement of the students. It supports the notion of Adams and Engelmann (1996) that direct instruction (DI) improves the student population's performance rate. Its objective is to present information as quickly and effectively. While studies in DI indicate that using the model improves mathematics outcomes (Przychodzin et al., 2004), another study argues that using this method in teaching and learning is associated with student disengagement and non-participation in the subject (Ewing, 2011).

On the other hand, the results of the constructivist approach group show a p-value of 0.000, which is also less than 0.05. It is seen here that there is sufficient evidence to conclude that the constructivist approach increased the academic achievement of the students. A study by Ayaz and Sekerci (2015) and Samaresh (2017) demonstrates that the constructivist approach positively affects students' academic achievement. They are not just a passive recipient of the learning but a part of the learning process of constructing knowledge through experience. In the lesson on polynomial functions, a series of activities were given, leading to the concept of the lesson. Group activities, pairing activities, games, and individual tasks were provided. A constructivist teacher should understand that experience increases students' knowledge (Kusuma et al., 2021). Learning about the polynomial functions and circles through different activities promotes students' engagement and interaction with the topic.

Table 4 presents the *t*-test analysis of two independent sample groups of post-tests on the control and experimental group on their academic achievement.

Table 4. t-Test Analysis of the Significant Difference in the Post-test Academic Achievement

Groups	n	Post-test Mean	SD	P-value	Decision
Direct Instruction	44	30.343	6.58	0.086	Fail to reject H_0
Constructivist	43	32.65	5.78		

The table shows the post-test mean scores of the direct instruction group (30.34) and constructivist group (32.65). Since the p-value is 0.086, which is greater than α = 0.05, the null hypothesis is not rejected. Therefore, there is no sufficient sample evidence to conclude that the academic achievement of the respondents significantly differs using the direct and constructivist approaches in teaching mathematics. It implies that the two methods had the same effect on the learners. However, the experimental group has a higher mean at 32.65, and an SD of 5.78 means that, on average experimental group performed marginally consistently and slightly better than the control group. The constructivist approach makes the lesson engaging and more concrete for the students. The formation of concepts through activities enables the learners to participate actively in the learning process.

While the approach benefited the students, it is challenging for the teachers to restructure their classrooms to accommodate this teaching approach. Some variables need consideration in using the constructivist approach. Among these are time constraints, the capacity of the learner to do the tasks, and the class size. Answering a series of activities requires ample time, especially for those challenged students who need time to connect and reconnect previous knowledge to the present lesson. The teacher is, therefore, a facilitator to those who require assistance in the class and those who are advancing. The teacher is expected to be sensitive to their needs and will promptly address students' concerns to maximize their engagement. Otherwise, students will linger longer on the present task and have difficulty moving on to the next phase of the activity. Thus, thorough lesson preparation is needed, and activities should suit their abilities to engage actively and explore the lesson.

The constructivist approach is ideal for self-regulated learners who can manage their learning—the kind of learners who can get the concepts and make connections hastily- and students who have difficulty understanding the abstract concept of the subject. The approach has a technique to concretize the concept for in-depth learning. However, there were constraints for those who could not see the connection in the lesson activity, which resulted in disengagement from the lesson; thus, lessons need to be adjusted to accommodate those learners. Some math lessons are procedural and abstract, and exploring them might lead to anxiety and confusion if students are left to do the activities and tasks independently. They are teaching these small class sizes is ideal for accommodating the student's queries. Teachers' presence in this approach is significant in guiding them. When the teachers mentor and guide the learners on the procedures and key points that the student missed, it will help lessen the lesson's confusion. Kirschner & Clark (2004) argue that practical unguided learning is less effective and less efficient than the learning approaches that place a solid effort to guide the student learning process. Guidance of the teacher is a must to address the doubts and confusion. Being the facilitator of learning does not mean leaving the student to learn and explore on their own but rather walking together with the students in the learning process.

4. Conclusions

The study was conducted to verify the effectiveness of the constructivist approach compared to direct instruction in teaching polynomial functions and circles. A quasi-experimental design was used. Participants were selected through convenient sampling. The academic achievement after the two interventions of the two groups was then compared. The researcher concluded that the direct and constructivist approaches improved the students' academic achievement. Both methods have significant effects on the students in learning Mathematics. Using direct instruction is a straightforward approach to teaching Mathematical lessons. This can be used to teach foundational knowledge, symbols, and conventions. However, it has been observed that listening to lectures leads to disengagement from the lesson and a monotonous lesson flow. Active engagement in the class is kept in the constructivist approach, which also significantly impacts academic achievement. Activities lead to understanding the lesson, have experiential motivation for the learners, and improve interaction with the lesson material, peers, and teacher. Students are observed discussing their ideas and asking questions with their classmates and teacher.

Moreover, the data indicate that using the constructivist teaching approach results in a slightly higher mean score and shows marginally consistent performance than direct instruction. With this, the constructivist teaching method is recommended as another paradigm in teaching Mathematics. The approach makes the lesson engaging and meaningful to students through collaborative works, games, and pairing activities. Using the approach in teaching polynomial functions and segments of circles promotes active participation in the learning process from the students. This is seen when the student remarked that they had fun playing games while learning.

Teaching higher Mathematics in Grade 10 requires solid foundational concepts from the previous years, which is apparent in the spiraling of the curriculum. While constructivists improved student engagement, active involvement in the lesson, and their performance, the researcher observed that mathematical ideas, such as definitions and conventions, need to be directly pointed out for the students to understand. A balance of the use of the direct instruction and constructivist approach is advised in teaching more abstract concepts in Mathematics for the learners to have a schema of past knowledge when performing the present activities. Exploring other instructional models in the context of Filipino learners' culture and practices are recommended for an advanced study. Future research studies are suggested to compare the constructivist approach to other contemporary teaching methodologies.

Declaration of Conflict of Interest

The researcher conducted the research while she was connected with DepEd. She further declares that her study respondents were her students, and her association with the respondent does not affect the study's results in general.

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