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Enhancing Learning Achievement and Motivation in Mathematics: The Effect of Online Instruction on Simplifying Radical Expressions

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Research Article

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Abstract

Background/purpose. This study investigates the impact of online instruction on students' learning achievement and motivation in simplifying radical expressions in mathematics. With the increasing integration of technology in education, understanding its effectiveness compared to traditional modular learning is essential. The main purpose is to compare the effects of online versus modular instruction on student outcomes, particularly focusing on motivation and achievement among Grade 9 students.

Materials/Methods. This research utilized a mixed-methods embedded design, integrating a quasi-experimental methodology with qualitative survey data. Sixty Grade 9 students from a public high school in Nueva Ecija, Philippines, were purposefully assigned to control (modular) and experimental (online) groups. Data collection involved a 50-item proficiency test, the Modified Course Motivation Survey, and an open-ended survey concerning instructional experiences. Quantitative data were analyzed using descriptive statistics and t-tests, whereas qualitative responses were analyzed using thematic analysis.

Results. Findings revealed that both instructional methods improved students' achievement and motivation in mathematics. However, online instruction was significantly more effective, especially in enhancing motivation. Students reported that online activities were engaging, participatory, and promoted independent learning, despite some challenges. Post-intervention, the online group demonstrated higher motivation and achievement levels compared to the modular group.

Conclusion. The study concludes that online instruction is more effective than modular learning in increasing motivation and learning achievement in mathematics. The engaging and interactive nature of online strategies fosters active participation and independent learning, suggesting that integrating technology into teaching practices can significantly enhance educational outcomes.

1. Introduction

Mathematics is widely viewed by students as one of the most challenging subjects, often associated with negative attitudes, anxiety, and lower academic achievement than in other fields (Dörnyei & Ushioda, 2011; Baumeister, 2016). A Gallup poll cited by Fleming (2014) confirmed this view, ranking mathematics as the hardest school subject. One area where students especially struggle is simplifying radical expressions, a Grade 9 skill often seen as abstract and unnecessary. Research shows that students frequently misuse properties of radicals and develop misconceptions, particularly when their foundational knowledge of exponents, prime factorization, and roots is weak (Ozkan & Ozkan, 2012; Crisan, 2012). These challenges hinder not only their mastery of the topic but also their success in advanced mathematical concepts like algebra and calculus.

The COVID-19 pandemic caused further disruptions to mathematics instruction as schools shifted to distance learning methods mandated by the Department of Education (DepEd Order No. 12, s.2020). Modular distance learning depended heavily on parents as facilitators, while online instruction required reliable technological resources and adaptability, presenting significant challenges for both teachers and students (Malipot, 2020; Llego, 2020). Despite these obstacles, studies have indicated that online instruction can boost student independence, retention, and higher-order thinking skills (Angiello, 2010; Garbett, 2011). It has also been shown to improve satisfaction and motivation in learning environments (Kim & Frick, 2011; Wang, 2013).

Motivation plays a vital role in student success, as it guides behavior toward learning goals and boosts engagement (Amrai et al., 2011; Wigfield et al., 2016). Tokan et al. (2019) also highlight that intrinsic motivation positively affects learning behaviors and results.

Although several studies have examined online instruction and motivation in education, limited research has specifically examined their combined effects in simplifying radical expressions, where misconceptions remain prevalent and mastery is essential for progression in mathematics. To address this gap, the present study investigates the impact of online instruction on students' learning achievement and motivation in mathematics, with the aim of proposing instructional strategies that enhance student outcomes in this fundamental competency. Based on Constructivist Learning Theory and Keller's ARCS Model of Motivation, this study conceptualizes online instruction as an interactive process, whereby learners actively develop mathematical understanding through guided activities, feedback, and collaboration. Motivation is regarded not merely as a by-product but as a central factor influencing engagement, persistence, and achievement, thereby serving as a critical dimension in comparing online and modular instructional modalities.

Generally, this study aimed to determine and investigate the effects of teaching simplifying radical expressions in Mathematics using online instruction, particularly on the students' learning achievement and motivation level. Specifically, this research sought to answer the following questions:

1. How may the control and experimental groups be described before using modular and online instruction based on i) Learning Achievement, and ii) Motivation Level Towards Mathematics?

2. How may the control and experimental groups be described after the use of modular and online instruction based on i) Learning Achievement, and ii) Motivation Level Towards Mathematics?

3. Is there a significant difference in the students' learning achievement and motivation level in Mathematics between the control and experimental groups before and after the experiment?

4. Is there a significant difference between the control and experimental groups before and after the experiment in terms of their i) Learning achievement, and ii) Motivation level towards Mathematics?

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5. How may the experiences of the students in the online and modular instruction be described in terms of the i) Teacher's Strategies; ii) Learning Activities; and iii) Motivation?

2. Literature Review

2.1. Growth of Online Instruction

Online instruction has experienced a consistent increase in popularity globally, supported by research indicating that enrollments in online courses continue to grow at a rate surpassing that of traditional educational methods. In the United States, the number of students undertaking at least one online course grew by more than 570,000 within a single year, coinciding with the expansion of Massive Open Online Courses (MOOCs) (Allen & Seaman, 2013; Bair & Bair, 2011). This development underscores the worldwide demand for accessible, adaptable, and technology-enhanced education.

In the Philippines, even prior to the pandemic, institutions such as AMA University, University of the Philippines, Polytechnic University of the Philippines, and others were already offering online courses (Katigbak, 2018). The COVID-19 pandemic expedited this transition, compelling educational institutions to implement online pedagogy to ensure the continuity of learning. This transition necessitated the adoption of technologies that facilitated online instruction, leading to innovative developments that helped education adapt to the new normal (Chen et al., 2020; Dhawan, 2020; Liguori & Winkler, 2020).

2.2. Effects of Online Instruction

Studies have shown mixed results on the effectiveness of online instruction. While some research suggests that online courses are highly interactive, cost-effective, and can boost student independence and critical thinking skills (Angiello, 2010; Christianson et al., 2002; Britt, 2006), others argue that they don't always live up to expectations. However, online courses are seen as a valuable alternative to traditional courses, which can increase access to higher education (Russel, 2000, as cited in Bair & Bair, 2011). Additionally, students have praised innovative online formats, such as multimedia presentations, for increasing engagement and the quality of discussions (Thor et al., 2017).

On the other hand, some research contradicts these findings, with results showing that students in online courses may perform worse than those in face-to-face settings (Warren & Holloman, 2005; Heppen, 2016). Faculty perceptions are also varied—some highlight flexibility and rewarding teaching experiences (Li & Akins, 2005), while others consider online teaching inferior, harder to manage technologically, and more prone to academic dishonesty (Wilson, 2001; Moralista & Oducado, 2020). Nevertheless, prior studies also indicate that faculty who regularly teach online tend to have more positive views of its effectiveness (Lee et al., 2015).

2.3. Challenges in Online Instruction

Transitioning from traditional to online instruction has posed many challenges for students, faculty, and institutions. Students often struggle with technical problems, distractions, managing their time, staying motivated, unclear course expectations, reduced in-person interaction, new technologies they're unfamiliar with, and uncertainty about their future (Friedman, 2020). These challenges show how tough it can be to adapt to a new learning format that demands more self-discipline and independence.

Online instruction faces more than just individual challenges. Broader issues also impact its success. These include limited access to reliable technology, low digital literacy, and the limitations of current platforms, all of which make smooth implementation tough (University of Illinois, n.d.). These barriers highlight the ongoing digital divide, especially in developing countries, and emphasize

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the need for institutions to invest in training, infrastructure, and support systems to make online learning effective and equitable.

2.4. The Role of Motivation in Learning

Motivation, derived from the Latin verb movere, meaning "to move," refers to the internal or external drive that prompts individuals to make choices, engage in actions, and persist toward goals (Dörnyei & Ushioda, 2011). It is an essential factor in student learning, as it influences behavior, effort, and achievement. Motivation is rooted in the desire to change one's behavior, thoughts, emotions, self-concept, environment, or relationships (Baumeister, 2016). Because of its vital role in learning, teachers are encouraged to help foster and develop student motivation to maximize classroom achievement (Valerio, 2012).

There are two primary types of motivation: intrinsic and extrinsic. Intrinsic motivation arises from personal interest and enjoyment in a task and has been strongly associated with higher academic achievement and greater satisfaction in learning (Stirling, 2014; Tohidi, 2011). Studies have shown a direct positive link between intrinsic motivation and student performance (Niehaus, 2012; Cortright et al., 2013). Conversely, extrinsic motivation stems from external factors such as rewards and punishments (Tohidi, 2011). While some research reports that extrinsically motivated students demonstrate lower engagement and weaker outcomes (Crumpton & Gregory, 2011), other studies suggest that extrinsic motivation can still positively influence academic performance (Ogundokun et al., 2010).

2.5. Teaching and Learning Simplifying Radical Expressions

Radicals are widely considered among the most challenging topics in mathematics due to the complexity of the concepts and the persistent misconceptions students hold about radical signs and related vocabulary (Crisan, 2012). Many of these difficulties stem from a lack of mastery of prerequisite topics such as irrational numbers, absolute value, factoring, and basic arithmetic operations (Ozkan, 2011). Without a strong foundation, students often resort to memorization rather than developing a deeper conceptual understanding of radical expressions. This gap in comprehension highlights the need for well-structured and targeted instructional strategies.

Mathematics educators have proposed various methods to improve student understanding of radicals. For instance, Hsu et al. (2012) suggested a paper-folding activity to help learners visualize the geometric properties of square roots, while Blitzer (2010) emphasized the importance of reinforcing the Product Rule for simplification. Ozkan and Ozkan (2012) further recommended addressing prerequisite deficiencies before teaching radicals, extending instructional time, and adopting student-centered approaches. They also highlighted the role of appropriate teaching materials and technology in making abstract concepts more concrete. Overall, effective teaching of radicals requires detailed study, careful scaffolding, and interactive strategies that connect conceptual understanding with procedural skills.

3. Methodology

3.1. Research Design

This study used a mixed-methods approach with an embedded research design. In this design, both quantitative and qualitative data are collected, with one type complementing the other (Creswell, 2006). The investigation started with a quasi-experimental quantitative analysis, which was then supplemented by a qualitative review of learners' responses to open-ended survey questions. This integration provided deeper insights into students' experiences with online instruction.

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3.2. Research Locale

This research study was conducted at National High School in Nueva Ecija. This school is one of the top-performing schools in the field of mathematics in the Division of Nueva Ecija. During the pandemic, this school offered online distance learning as well as modular distance learning as its learning modalities. Since this research compared online and modular instruction, data can be collected at this institution.

3.3. Subjects of the Study

The subjects of this study were Grade 9 students from the National High School who were high- or low-achieving. The participants of this study consist of eighteen (24) male and thirty-three (36) female students. The subjects were divided into two groups: the control group, which underwent modular learning, and the experimental group, which was exposed to online instruction in Mathematics. There were fifteen (15) subjects for each set in each group, with a total sample of sixty (60). Samples for the actual experiment were selected using purposive sampling. Subjects with access to the internet and have the required technology were chosen for the experimental group, while subjects who do not have access to the internet and do not have the required technology were chosen for the control group.

3.4. Research Instruments and Validation

In obtaining the data needed for the different stages of this study, the researcher utilized the following instruments:

Proficiency Test in Simplifying Radical Expressions. This instrument was a teacher-made test consisting of 50 multiple-choice items with simplifying radical expressions as the focus competency. This was used to assess the subjects' learning achievement before and after the experiment. The students were given one point for every correct response. Based on the reliability statistics done using SPSS, the Proficiency Test for Simplifying Radical Expressions had a Cronbach's Alpha of 0.813. The instrument had good reliability.

Modified Course Motivation Survey (MCMS). The Modified Course Motivation Survey (MCMS) was designed to measure the level of motivation of the subjects of this study before and after the conduct of the experiment. It was adopted from an existing instrument, the Course Interest Survey, which many authors already used to measure students' motivation. Based on reliability statistics conducted in SPSS, the Modified Course Motivation Survey had a Cronbach's Alpha of 0.975. The instrument had an excellent reliability.

Open-Ended Survey. This survey is composed of a question about the subjects' experiences during the online or modular instruction (based on the groups they belong to) in terms of the teacher's strategies used, learning activities, and motivation. This instrument aims to gather evidences about how the subjects perceived online and modular instruction.

3.5. Data Analysis Technique

The data gathered in this study were organized, presented, analyzed, and interpreted using statistical tools such as the t-test for independent and dependent samples, and statistical software such as Excel 2019 and Statistical Packages for the Social Sciences (SPSS).

1. To describe the students' mathematics learning achievement before and after the experiment, scores and mean score in each group were used and were interpreted using the following interval: 41 – 50 (Excellent), 31 – 40 (Very Satisfactory), 21 – 30 (Satisfactory), 11 – 20 (Fair), & 0 – 10 (Needs Improvement).

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2. To describe the level of motivation of the two groups before and after the experiment, scores and weighted mean were utilized and interpreted based on the scale used by Mohammed Al-Ta'ani (2018). The intervals were as follows: 4.50 – 5.00 (Highest), 3.50 – 4.49 (High), 2.50 – 3.49 (Moderate), 1.50 – 2.49 (Low), and 1.00 – 1.49 (Lowest).

3. To determine if there is a significant difference between the pre-test and post-test scores in each group, the t-test for dependent samples was used.

4. To determine if there is a significant difference between the motivation level before and after the experiment in each group, t-test for dependent samples was also employed in data analysis.

5. To determine if there was a significant difference in learning achievement between the control and the experimental groups before and after the experiment, a t-test for independent samples was used.

6. To determine if there is a significant difference in the level of motivation between the control and the experimental groups before and after the experiment, t-test for independent samples was used in data analysis.

7. Thematic content analysis was applied to describe the students' experiences with online instruction in terms of teacher strategies, learning activities, and motivation.

4. Results

4.1. Learning Achievement and Motivation Level Towards Mathematics of the Subjects Before the Experiment

4.1.1. Learning Achievement

Learning achievement is a measure of students' success in learning a particular subject. In this study, learning achievement refers to students' test scores on the Proficiency Test in Simplifying Radical Expressions.

Figure 1 shows the data on the subjects' learning achievement before the conduct of modular instruction (for control groups) and online instruction (for experimental groups).

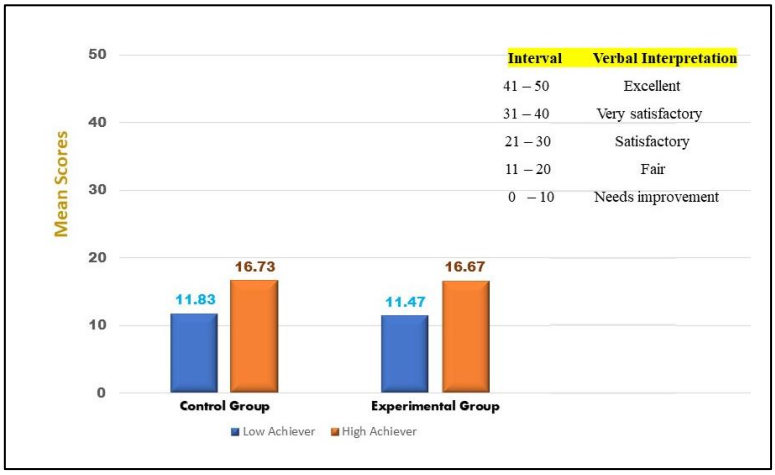

Figure 1. Learning Achievement Before the Experiment

The low achiever subjects under the control and experimental groups obtained a mean score of 11.83 and 11.47, verbally described as "fair". On the other hand, the high achiever subjects under the control and experimental groups performed "fairly" on the pretest with a mean score of 16.73 and 16.67, respectively. Among the groups, the high-achiever subjects in the control group obtained the highest mean score (16.73). It can be deduced from the data presented in the figure that the learning

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achievement of the subjects before the implementation of the respective modes of instruction was poor, as reflected in their mean scores in the 50-item pre-test.

4.1.2. Motivation Towards Mathematics

The Modified Course Motivation Survey was administered to measure the students' motivation levels before the experiment. The mean and weighted mean were determined, and the results are summarized in Figure 2.

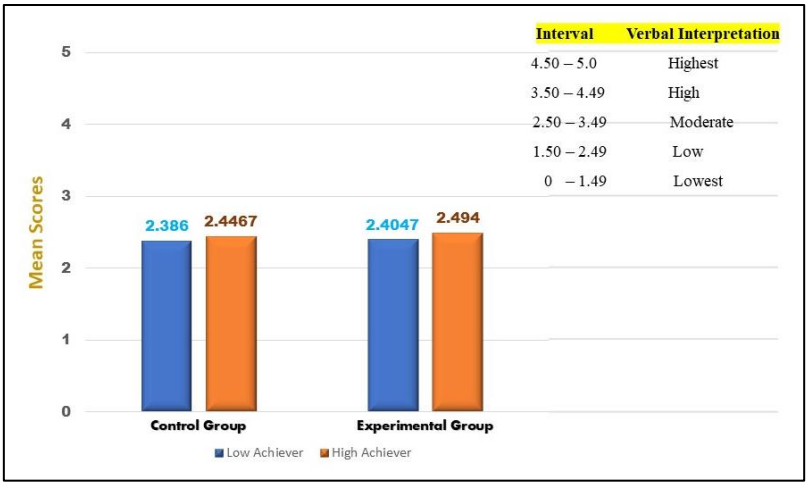

Figure 2. Motivation Level Towards Mathematics Before the Experiment

Based on the table presented above, subjects under the experimental group were more motivated than the subjects under the control group though the difference is not significantly large enough. Low motivation level was exhibited by the low achiever subjects with a mean of 2.3860 for the control group and 2.4047 for the experimental group. On the other hand, high achiever subjects under the control and experimental groups obtained scores of 2.4467 and 2.4940, respectively, which was verbally interpreted as a “low” level of motivation. High achiever subjects under the experimental group obtained the highest score on the motivation survey, with a score of 2.4940.

4.2. Learning Achievement and Motivation Level Towards Mathematics of the Subjects After the Experiment

4.2.1. Learning Achievement

The study assessed the impact of modular and online instruction on student proficiency in simplifying radical expressions. Figure 3 summarizes the results.

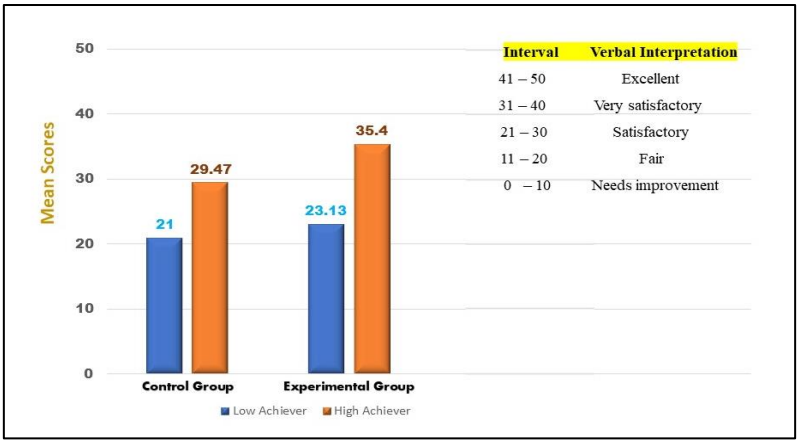

Figure 3. Learning Achievement After the Experiment

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Posttest mean scores showed that students in the experimental group outperformed those in the control group. Low achievers in both groups improved from "fair" to "satisfactory," with mean scores of 21.00 (control) and 23.13 (experimental). High achievers in the control group performed satisfactorily (mean score of 29.47), while high achievers in the experimental group achieved a "very satisfactory" performance with a mean score of 35.40. Overall, the control and experimental groups showed satisfactory performance with mean posttest scores of 25.23 and 29.27, respectively. Both groups exhibited significant improvement from their pretest mean scores (14.03 for control, 14.07 for experimental), highlighting the positive impact of both instructional methods.

4.2.2. Motivation Towards Mathematics

The Modified Course Motivation Survey was administered once more; however, this iteration aimed to assess the students' motivation levels subsequent to the experiment. The results of the data analysis are presented in Figure 4.

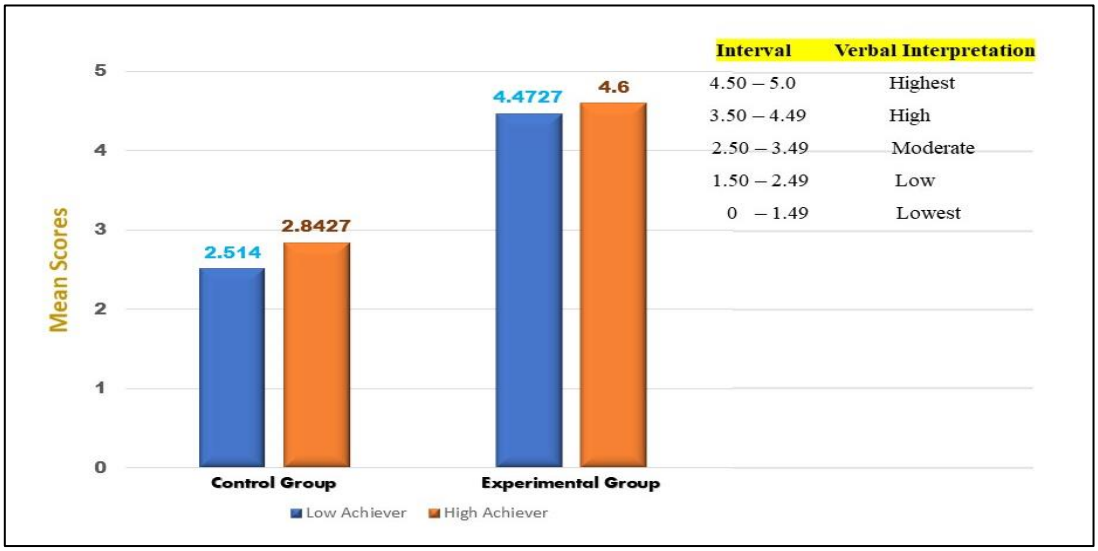

Figure 4. Motivation Level Towards Mathematics After the Experiment

After the experiment, the Modified Course Motivation Survey showed that students in the experimental group achieved the highest motivation level toward mathematics, while the control group attained a moderate level. Both groups experienced increased motivation following their respective instructional methods. Among low achievers, the control group reached a "moderate" motivation level (mean score 2.5140), whereas the experimental group reached a "high" level (mean score 4.4727). High achievers in the control group had a "moderate" motivation level (mean score 2.8427), while those in the experimental group showed the most notable improvement, reaching the "highest" motivation level (mean score 4.6). Overall, the experimental group exhibited a significantly higher level of motivation (mean 4.54) than the control group (mean 2.68). This indicates that modular and online instruction positively impacted students' motivation toward mathematics.

4.3. Significant Difference in the Students' Learning Achievement and Motivation Level in Mathematics Before and After the Experiment

4.3.1. Learning Achievement

Pre-test and post-test mean scores were analyzed using a paired-samples t-test (t–test for dependent samples) to determine whether there was a significant difference in students' learning achievement between the control and experimental groups before and after the experiment.

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Table 1. Paired Sample t-test for the Learning Achievement

			Paired Differences			
			Mean	SD	t-value	p-value
Low Achiever	Control	Pre-test Posttest	-9.667	1.496	-25.026	0.00
	Experimental	Pre-test Posttest	-11.667	2.440	-18.520	0.00
High Achiever	Control	Pre-test Posttest	-12.73	2.738	-18.013	0.00
	Experimental	Pre-test Posttest	-18.733	3.262	-22.245	0.00
Overall	Control	Pre-test Posttest	-11.200	2.670	-22.972	0.00
	Experimental	Pre-test Posttest	-15.200	4.574	-18.200	0.00

In general, the findings indicate a significant difference between the pre-test and post-test scores of the control group, t = -22.972, p = 0.000. Moreover, the pre-test and post-test scores of the experimental group were found to be significantly different, t = -18.20, p = 0.000. This implies that the learning achievement of the low and high achievers in the control and experimental groups improved after the implementation of modular instruction (for the control group) and online instruction (for the experimental group).

4.3.2. Motivation Towards Mathematics

Table 2 summarizes the statistical analysis of the data collected from the subjects regarding their motivation for mathematics.

Table 2. Paired Sample t-test for the Motivation Level Towards Mathematics

			Paired Differences			
			Mean	SD	t-value	p-value
Low Achiever	Control	Before After	-0.128	0.672	-7.376	0.00
	Experimental	Before After	-2.0680	.3021	-26.509	0.00
High Achiever	Control	Before After	-0.396	.19592	-7.828	0.00
	Experimental	Before After	-2.106	.26710	-30.538	0.00
Overall	Control	Before After	-0.262	0.198	-7.240	0.00
	Experimental	Before After	-2.087	.281	-40.700	0.00

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Based on the statistical analysis, there is a significant difference in motivation between the pre- and post-experiment levels for the control group, t = -7.240, p = 0.000. Data also revealed that there is a significant difference between the level of motivation before and after the experiment for the experimental group, t = -40.70, p = 0.000. This implies that the motivation levels of the low achievers and high achievers, and the summary, improved after the implementation of the respective modes of instruction.

4.4. Significant Difference Between the Control and Experimental Groups Before and After the Experiment in Terms of Learning Achievement and Motivation Level Towards Mathematics

4.4.1. Learning Achievement

An Independent Samples t-test was conducted to compare the pre-test and posttest scores of students in the control and experimental groups. The summary of results was presented in Table 3.

Table 3. Independent Sample T-test for the Learning Achievement

			Mean	SD	t-value	p-value
Low Achiever	Pre-test	Control	11.33	1.799	-.226	0.823
		Experimental	11.47	1.407		
	Posttest	Control	21.00	2.104	-2.63	0.014
		Experimental	23.13	2.326		
High Achiever	Pre-test	Control	16.73	2.154	0.083	0.934
		Experimental	16.67	2.225		
	Posttest	Control	29.47	2.924	-4.68	0.000
		Experimental	35.40	3.942		
Overall	Pre-test	Control	14.03	3.368	-0.039	0.969
		Experimental	14.07	3.216		
	Posttest	Control	25.23	4.981	-2.57	0.013
		Experimental	29.27	7.002		

At a 0.05 significance level, results showed no significant difference between groups in the pre-test scores for both low achievers (t = -0.226, p = 0.823) and high achievers (t = -0.083, p = 0.934), indicating that both groups were comparable in learning achievement before the intervention.

However, posttest results revealed a significant difference between the control and experimental groups for both low achievers (t = -2.63, p = 0.014) and high achievers (t = -4.68, p = 0.000), as well as in the general sample (t = -18.20, p = 0.013). This led to rejecting the null hypothesis, confirming that the groups differed significantly after the intervention.

4.4.2. Motivation Towards Mathematics

The results of the statistical analysis were summarized in Table 4.

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Table 4. Independent Sample T-test for the Motivation Level Towards Mathematics

			Mean	SD	t-value	p-value
Low Achiever	Before	Control	2.3860	0.12552	-0.390	0.700
		Experimental	2.4047	0.13669		
	After	Control	2.5140	0.12258	-30.75	0.000
		Experimental	4.4727	0.21413		
High Achiever	Before	Control	2.4467	0.15814	-0.801	0.430
		Experimental	2.4940	0.16556		
	After	Control	2.8427	0.17515	-28.24	0.000
		Experimental	4.6000	0.16562		
Overall	Before	Control	2.42	0.144	-0.853	0.397
		Experimental	2.45	0.156		
	After	Control	2.68	0.224	-34.00	0.000
		Experimental	4.54	0.199		

The study found no significant difference in motivation levels between the control and experimental groups before the intervention for both low achievers (t = -0.390, p = 0.700) and high achievers (t = -0.083, p = 0.934), with a general finding of no difference (t = -0.039, p = 0.969). This confirmed that both groups were initially comparable in their motivation toward mathematics.

After the intervention, however, there was a significant difference in motivation levels between the groups across low achievers (t = -30.75, p = 0.000), high achievers (t = -28.24, p = 0.000), and across all groups (t = -34.00, p = 0.000). The null hypothesis was rejected, indicating that the experimental group's motivation was significantly higher than the control group's after the instruction.

4.5. Experiences of the Learners on Online and Modular Instruction

The study examined student experiences with online and modular instruction. Key findings included:

Teacher's Strategies: In online instruction, students found the strategies engaging and aligned with the learning objectives, using platforms like Prezi and Google Meet to enhance interactivity. In modular instruction, students valued independent learning, though some found it challenging due to the lack of direct support.

Learning Activities: Online activities were perceived as sequential and encouraged active participation, making them accessible to various student levels. Modular activities also followed a sequential format but were challenging and required precision, which some students found demanding.

Motivation: Online instruction significantly increased student motivation due to interactive, engaging content. In contrast, modular instruction was only "somewhat motivating," with limited engagement and feedback, leading to a moderate improvement in motivation.

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5. Discussion

The study investigated the effects of modular and online instruction on students' learning achievement and motivation in simplifying radical expressions. Results demonstrated that both instructional modes improved student outcomes; however, online instruction produced significantly higher gains.

5.1. Learning Achievement

Pre-test scores showed no significant difference between groups, confirming they were comparable at the start. Post-test results, however, revealed that the experimental group scored higher than the control group. This indicates that online instruction promoted deeper understanding and retention, consistent with the findings of Yokoyama (2018) and Elfaki et al. (2019), who concluded that online environments improve student performance.

5.2. Motivation Toward Mathematics

Both groups exhibited improvements in motivation; however, the advancements were more conspicuous within the experimental group. The interactive and engaging characteristics of online learning presumably contributed to this disparity, corroborating the findings of Harandi (2015), who identified a significant correlation between online instruction and student motivation. Likewise, Kim and Frick (2011) underscored that motivated students exhibit higher levels of engagement and achievement.

5.3. Student Experiences

The qualitative findings further clarify these results. Online learners appreciated interactive strategies and accessible activities, which facilitated heightened motivation and active participation. Modular learners acknowledged the advantages of autonomous study but faced challenges due to limited feedback and support. These findings align with the observations of Setiawan and Wiedarti (2020) and Tentama and Pranungsari (2014), who reported improved motivation when students were provided with interactive tools and motivational interventions.

5.4. Implications

The findings highlight the importance of integrating technology and interactive elements in mathematics instruction to enhance both achievement and motivation. While modular learning still benefits independent learners, online methods appear particularly effective for low achievers who require more engagement and scaffolding.

6. Limitations and Future Research

This study, although limited in scope, provides valuable insights that can serve as a foundation for future research endeavors. The relatively brief duration of the intervention offered a preliminary view of its immediate effects; extending the implementation period in subsequent studies may reveal even more significant and enduring impacts on achievement and motivation. The utilization of self-reported motivation surveys yielded direct insights from learners; future research could enhance this approach by incorporating additional measures to attain a more comprehensive understanding of student engagement. By concentrating on the specific skill of simplifying radical expressions, the study facilitated a clear and detailed analysis, and future investigations could expand exploration to other mathematical domains to improve generalizability. Lastly, conducting the study within a single school environment established a clearly defined context for analysis; future research across diverse schools and learning environments may broaden the applicability of the findings.

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7. Conclusion

Based on the findings of this study, the following conclusions were drawn:

1. The subjects, in general, got a fair learning achievement and a low level of motivation before the implementation of the modular instruction and online instruction. There was room for improvement in students' learning achievement. Moreover, there was a need to enhance the subjects' motivation.

2. The subjects, both from the control and experimental groups, achieved satisfactory learning outcomes. However, in terms of the level of motivation, the subjects in the experimental group had a higher motivation level. It could be inferred that the subjects' learning achievement and motivation improved after the implementation of modular, online instruction.

3. There is a significant difference in the learning achievement and motivation level of the subjects under the control and experimental groups before and after the conduct of the respective mode of instruction. The instructional mode used proved effective in improving students' learning achievement and motivation in mathematics.

4. There was no significant difference between the control and experimental groups before the experiment in terms of learning achievement and level of motivation. The subjects in the control and experimental groups were comparable or statistically the same before the experiment. On the contrary, there was a significant difference between the control and experimental groups after the experiment in terms of learning achievement and level of motivation. Online instruction is more effective in improving students' learning achievement and motivation levels.

5. Based on the subjects' experiences, in the conducted online instruction, the strategies used were engaging/interesting and appropriate to the lesson. The learning activities during the online instruction were sequential, appropriate to the level of the students, and called for active participation. In terms of motivation, the students had an increased motivation. In modular instruction, the teacher's strategy was associated with independent learning and difficulty in learning. In terms of learning activities, it was found that in modular instruction, the activities were sequential and challenging. Modular instruction was somewhat motivating based on their responses.

8. Suggestion

Based on the findings, it is recommended that educators prioritize the integration of online instructional strategies to improve students' motivation and achievement in mathematics. The study clearly shows that online instruction is more effective than modular learning in enhancing both learning outcomes and motivation, primarily because of its engaging, interactive content. Teachers should utilize digital platforms such as Prezi and Google Meet, which have been found to promote active participation and facilitate sequential, level-appropriate learning activities.

Furthermore, adopting a blended approach that combines online and modular methods can address the limitations of each mode. While online instruction fosters engagement and motivation, modular learning can support independent learners, albeit with some challenges related to a lack of direct support. Providing additional scaffolding and feedback mechanisms in modular activities may help mitigate these issues.

It is also essential to train teachers in effective online teaching strategies that emphasize interactivity and student-centered activities, as these have been shown to significantly increase motivation. Schools and policymakers should invest in infrastructure and resources to support the widespread adoption of online learning, especially during disruptions like pandemics.

Finally, ongoing assessment and feedback should be incorporated to monitor student progress and sustain motivation. Future research could explore long-term impacts of online instruction and

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identify best practices for diverse student populations to ensure inclusive and effective mathematics education.

Declarations

Author Contributions. Mr. Mabuti served as the main author of this study. He was primarily responsible for the conceptualization, design, data collection, analysis, and manuscript writing. Dr. Ancheta contributed as the co-author, providing guidance in the formulation of the research framework, validating the methodology, and offering critical revisions to enhance the quality of the manuscript. Both authors reviewed and approved the final version of the paper.

Conflicts of Interest. The authors assert the absence of financial or personal affiliations that would unduly affect their work. All conclusions and analyses articulated in this work are exclusively derived from the data gathered and examined throughout the study process.

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Ethical Approval. The Institutional Review Board (IRB) ethically authorized "Enhancing Learning Achievement and Motivation in Mathematics: The Effect of Online Instruction on Simplifying Radical Expressions," safeguarding privacy and participant rights. Data will be securely stored with restricted access and anonymized or destroyed. Informed consent means participants know their rights, including the freedom to leave the study at any moment without penalty. Ethics have been taken to reduce risks, and the study follows privacy and dignity rules. This permission shows that the research will follow ethical norms.

Data Availability Statement. All data provided in this study were obtained and gathered at the University where the researchers were affiliated.

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