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The Influence of Teacher Clarity and Real-World Applications on Students' Achievement in Modern Algebra

Ahmad Khalid Mowahed*
Balkh University, AFGHANISTAN

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Abstract: This study tested hypotheses of a hypothetical model determining the influence of teacher clarity and real-world applications while teaching group theory concepts on students' achievement in modern algebra. The data collected from 139 undergraduate students were analyzed by regression analysis using Stata14's structural equation model building and estimation. The path regression analysis of the model using SEM model building and estimation confirmed the research hypotheses. First, the utilization of real-world application problems while teaching group theory concepts has a significant influence on students' achievement in modern algebra. Second, the clear presentation of group theory concepts by the teacher has a significant influence on students' achievement in modern algebra. Finally, both teachers' clear presentation of group theory concepts and utilization of its real-world applications have a significant influence on students' achievement in modern algebra.

Keywords: *Achievement, modern algebra, real-world applications, teacher clarity.*

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Introduction

Teachers' clarity in presenting university-level mathematics concepts is widely discussed and prioritized in teaching and learning. It's always heard from students complaining or appreciating teachers' presentation of mathematical concepts in the classroom. Teachers who clearly present mathematical concepts are well appreciated, while teachers who do not clearly present mathematical concepts are criticized by students. Teacher clarity is an important factor in student learning, it can help students learn better than those taught by unclear teacher (Chesebro, 2003). Teacher clarity refers to the teaching strategies and approaches that teachers utilize in a class to help students learn better the content of the subject (Bolkan et al., 2016). Hence, it is important for teachers to choose the appropriate instructional tools, techniques and strategies to ensure students' clear understanding of concepts and tasks (Arends, 2021). Therefore, positive teaching and learning practices are believed to improve academic achievement due to the nature of being facilitators of learning and engagement (Lee & Lim, 2017; Osher & Kendziora, 2010; Thapa et al., 2013). Although a multidimensional construct, teacher clarity is a construct defined "as a cluster of teaching behaviors that result in learners' gaining knowledge or understanding of a topic" (Cruickshank & Kennedy, 1986). Teaching behaviors may include, not exhaustively, the teaching method affecting learning (Fantuzzo et al., 1989), fluency of presenting concepts (Hiller et al., 1969), presenting concepts vaguely (Land, 1979), discontinuity in presenting concepts, speaking pace while teaching, clear communication with students while presenting course content (Civikly, 1992; Simonds, 1997), organization of course content (Alexander et al., 1979), and explicit teaching (Rosenshine, 1987).

The results of several studies indicate that teacher clarity can significantly improve cognitive learning, enhance students' success, promote positive emotional responses in students and enhance students' levels of engagement and motivation (Titsworth et al., 2015). In a recent study conducted by Roksa et al. (2017) showed that about two-thirds of the correlation between teacher clarity and student success was accounted by student motivation, engagement, and faculty interest. Furthermore, two meta-analyses by Titsworth et al. (2015) that aimed to explore relationship between teacher clarity and student learning has found that teacher clarity had significant effect on student learning. More specifically, the first meta-analysis of 144 articles and 73281 sample size has confirmed that teacher clarity contributed about 13%

* **Correspondence:**
Ahmad Khalid Mowahed, Balkh University, Mazar-e Sharif, Afghanistan. ✉ khalid.mowahed@gmail.com

of the variance in student learning. Moreover, Yagan (2021) showed that there was a significant relationship between teachers' classroom management and instructional skills as well as between students' mathematics achievement and attitudes toward mathematics. Teacher clarity can influence positive outcomes related to students' academic motivation and critical thinking (Loes & Pascarella, 2015). Very early correlational studies have also confirmed that teacher clarity influences students' achievement. For example, in an observational study, Good and Grouws (1977) showed that teacher clarity was an effective correlate of student achievement. In addition, Evans and Guymon (1978) studied the effects of teachers' clarity of explanation on students' learning and confirmed that teacher clarity was a significant correlate with students' achievement. Other studies on the use of vague terms while teaching a concept have shown that it was negatively correlated with students' achievement, whereas teaching concepts clearly was positively correlated with students' achievement (Land & Smith, 1979; Smith, 1977; Smith & Edmonds, 1978).

One of the observed aspects of traditional mathematics instruction is that mathematical content is introduced in its abstract form to students and there is less tendency to link it to the outside world of the classroom (Stone & Lewis, 2012). Hence, the disconnection of abstract math from real-life applications in traditional instruction results in students' disinterest and disengagement (Weinberger, 2004; Wilson, 2003). Therefore, there is a growing demand for qualified students in the fields of science, technology, engineering, and mathematics (Damlamian et al., 2013). Mathematics is considered the main pillar of preparing students with the knowledge and skills needed to solve real-world problems encountered in modern daily life situations (Li, 2013; Maaß et al., 2018). Teaching mathematical concepts using real-world applications can be extremely helpful for student learning. Using realistic mathematical modeling of real-life phenomena significantly improve students' applied problem-solving skills (Sevinc & Lesh, 2018). Indeed, exposing students to real-world applications of mathematical concepts can facilitate student learning, establish the connection between students' acquired knowledge and the phenomena happening in real-life situations, and ensure life-long learning of concepts. Although there is no consensus on a universal definition of real-world application, many facets have been reported in the literature. For example, Cooper and Harries (2005) and Pais (2013) view real world application of mathematical concepts as realistic math problems, while Blum and Borromeo Ferri (2009) and Frejd (2012) view real-world applications as modeling tasks in which the observed phenomenon is modeled according to explicit variables, parameters, and assumptions. Regardless of what we call it, real-world applications of mathematical concepts are important for teaching, learning, and understanding mathematics. These real-world problems are constructed with the aim of scaffolding students' conceptions and procedures involved in applying mathematical concepts to model the phenomenon or solving a realistic problem requiring the application of mathematical concepts. Indeed, exposing students throughout the teaching process to work on realistic problems by applying learned concepts can have a tremendous effect on their conception and overall academic achievement in a particular mathematical course.

Based on the empirical findings and the importance of teacher clarity and real-world problems in improving students' learning and achievement, the following hypotheses were developed and put into a hypothetical model (see Figure 1). Thus, the purpose of this research was to test the hypothetical model and determine the effects of utilizing real-world applications (RWA) considering the teacher's clarity (TC) of presenting mathematical concepts on undergraduate Afghan students' achievement in modern algebra (SAMA) courses focusing on the elementary group theory concepts.

The present study tested the following hypotheses based on the hypothetical model shown in Figure1 and to be tested with the collected data:

H_1: There is a significant positive relationship between the utilization of real-world application problems and students' achievement in modern algebra courses focusing on elementary group theory concepts.

H_2: Teachers' clear presentation of elementary group theory concepts has a significant relationship with students' achievement in modern algebra courses that focus on elementary group theory concepts.

H_3: The path analysis of teacher clarity → real-world problem utilization→ student achievement is statistically significant, implying that teacher clarity while explaining group theory concepts via real-world problems significantly predicts student achievement in modern algebra.

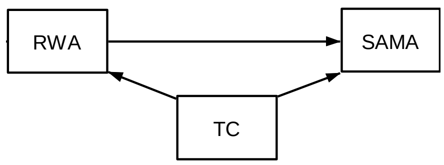


Figure 1. The Model of the Study Relating Predictors and Dependent Variable

The hypothesized path model (Figure 1) links teacher clarity predictor as a direct influence on students' achievement in modern algebra. It also considers the path from the teacher clarity predictor mediated by real-world applications of the concepts taught in class on students' achievement in modern algebra. The assumption here is that it is not only teacher clarity that influences students' achievement, but also the utilization of real-world problems connecting abstract concepts to some real-world concrete applications in the process of teaching that influences students' achievement. Finally, it was also hypothesized that the utilization of real-world applications of modern algebra concepts directly influences students' achievement in modern algebra The practical contribution of the above model to the teaching and learning of modern algebra is that it will support the argument that educators may shift from the abstract presentation of the concepts to an effective blended teaching approach connecting the abstract concepts of modern algebra with its real-world applications in order to ensure long-term learning and eventually enhance students' achievement in modern algebra.

Methodology

The relationship between two predictors (teacher clarity, real-world problems) and one dependent variable (students' achievement in modern algebra) was studied in this study. To test the hypothetical path-analytic model against the collected data, least square regression analysis and structural equation model building and estimation in Stata14 for estimation and data fitting procedures were used in order to test the hypothesized path-analytic model (Figure 1).

Sample, Procedure, Measures and Data Analysis

The participants of this study were 139 undergraduate students (40% male, 60% female) studying at the mathematics department of a faculty of education; in northern Afghanistan. The data on teacher clarity and real-world applications were collected by administering a two-item questionnaire on a scale of strongly disagree=1, disagree=2, slightly disagree=3, slightly agree=4, agree=5, and strongly agree=6.

Data collection for this study was conducted in two steps. In the first step, all participants had taken the modern algebra course focusing on elementary group theory concepts with the researcher. The elementary concepts of group theory were taught to all participants in a typical course of modern algebra for a semester of sixteen weeks. During the semester, the course followed the standard method of teaching group theory concepts by presenting definitions, theorems, proofs, examples and some real-world applications of the taught concepts at the end of an appropriate section focusing on interrelated concepts. The participants were assigned weekly assignments, including real-world problems from cryptography and complex computational problems. There was one midterm exam and one final exam to measure students' understanding of the concepts taught during the semester. The final exam scores of all participants were considered as their academic achievement in the modern algebra course.

In the second step, a two-item questionnaire was administered after the final exam of the semester to obtain the views and opinions of the participants on a scale of 1=strongly disagree to 6=strongly agree. The first item, asked students to rate overall teacher clarity of presenting group theory concepts and the second item asked them to rate how real-world problems affect their understanding of concepts during class teaching hours over the 16 weeks of the semester. The item translation from Farsi to English is a follows:

Item1 (Teacher Clarity): The teacher's presentation of group theory concepts in the modern algebra course was clearly presented and understandable for me.

Item2 (Real-World Applications): I better understand group theory concepts in modern algebra course whenever they are presented with applications.

Finally, data analysis was performed. Descriptive analysis was carried out by computing means standard deviations, skewness, kurtosis, and Spearman rank and Pearson correlation coefficients for the variables considered in the present study using Stata14. The multivariate normality of the data was evaluated by calculating Mardia's (1970) multivariate skewness and kurtosis coefficient, and Cronbach's alpha was calculated to determine the reliability of the two-item questionnaire.

Then inferential analysis was carried out to test the hypothetical model against the collected data using least square regression analysis and structural equation model building and estimation in Stata14 for estimation and data fitting procedures to test the hypothesized path-analytic model (Figure 1). All p-values for the effects of predictors (teacher clarity (TC) and real-world applications (RWA)) on the dependent variable (students' achievement in modern algebra (SAMA)) were two-tailed. All the outputs of the step-by-step analysis are reported in the tables and figures in the Results section.

Results

The present study aimed to determine the influence of teacher clarity (TC) and real-world applications (RWA) on student achievement in modern algebra (SAMA). The data collected from 139 undergraduate students using a two-item questionnaire asking students' views on teachers' clarity in presenting group theory concepts and using real-world applications, and students' final exam scores as their achievement in modern algebra courses were analyzed by Stata14. The results are reported below as descriptive and regression analyses.

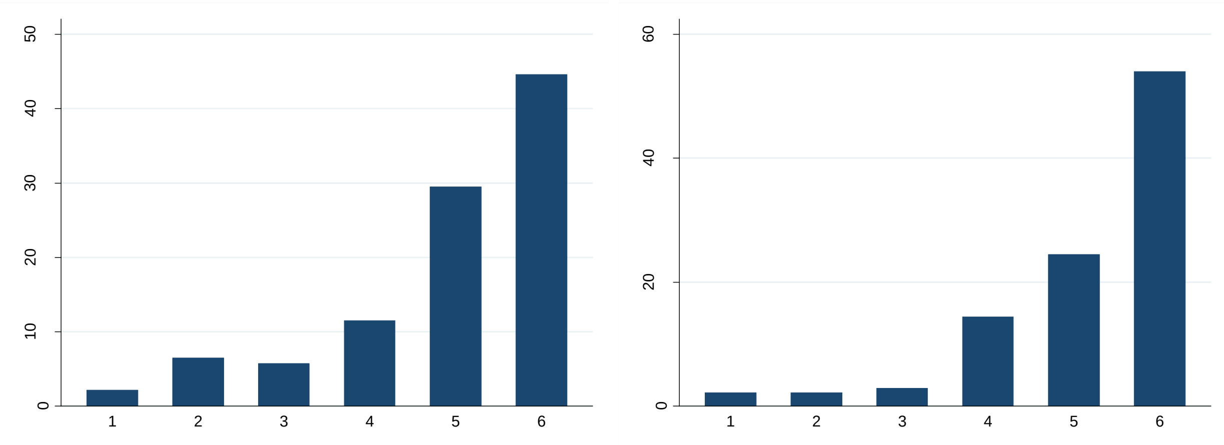
The descriptive analysis of the data showed that the mean score for teacher clarity (TC) was 4.935(SD=1.314). This indicates that participants agreed that the teacher clearly presented elementary group theory concepts and that the presentation was understandable for them in modern algebra courses. In addition, the mean score for real-world application (RWA) was 5.187 (SD=1.146). This shows that the participants agreed that using real-world applications of elementary group theory concepts makes the concept more understandable. Although it is difficult to obtain normally distributed data from a Likert scale, the skewness is below 2 and the kurtosis is below 7. According to the criteria set by Curran et al. (1996), this indicates that normality was not severely violated for all three variables.

Table 1. Descriptive Analysis for TC, RWA, and SAMA

Variable	Mean	SD	Skewness	Kurtosis
TC	4.935	1.314	-1.302	3.892
RWA	5.187	1.146	-1.705	5.912
SAMA	**16.576**	**11.464**	**0.940**	**2.885**

TC: Teacher Clarity, RWA: Real-World Applications, and SAMA: Students' Achievement in Modern Algebra

Bar graphs for the percentage ratings of teacher clarity and real-world applications are shown in Figure 2. Both bar graphs indicate that most participants agreed that teacher clarity and using real-world applied problems can influence students' achievement in modern algebra.



(a) *(b)*

Figure 2. (a) TC Rating Percentages, and (b) RWA Rating Percentages

To test the research hypotheses, the analysis was carried out using least square regression analysis and structural equation model building and estimation in Stata14. First, the multivariate normality of the data was evaluated by calculating Mardia's (1970) multivariate skewness and kurtosis coefficients. These values were obtained by running Mardia's skewness test to be 5.972 ($\chi^2 = 142.881, p < .000$) and kurtosis test to be 18.279 ($\chi^2 = 12.454, p < .000$)). As suggested by Raykov and Marcoulides (2008), the value of Mardia's multivariate skewness coefficient, 5.972, was less than $p(p+2) = 2(4) = 8$, where p is the total number of items = 2. This implies that the data were ready for least square regression and structural equation modeling analyses to test the hypotheses. Since it is obvious that teachers' clear presentation of group theory concepts and using real-world applied examples influence their achievement in modern algebra, there is no need to run a factor analysis for these two items. Furthermore, Cronbach's alpha for the purpose of determining the reliability of the two-item questionnaire was .477, which was below the required value of .700. One reason for not meeting this criterion was the small number of items in the questionnaire. This may imply that other dimensions of the two predictor variables must be added to the questionnaire to obtain the required value and understand other dimensions of the predictors. This could not be done in this study because we no longer had access to the participants and they had already completed their studies. To check the correlation among variables, the Pearson and Spearman's correlation matrices were calculated, respectively, and the results are given in Tables 2 and 3. Finally, we conducted SEM model building and estimation of variables according to the hypothetical model given in Figure 1 to test the research hypotheses, and the results are given in Table 4. The overall coefficient of determination(CD) was around 0.121, meaning that the two predictors (TC & RWA) contributed to almost 12% of variance in the dependent variable(SAMA)

Table 2. Pearson's Correlation Matrix for TC, RWA and SAMA

Variable	TC	RWA	SAMA
TC	1.000		
RWA	.316**	1.000	
SAMA	**.225****	**.266****	**1.000**

** indicate statistical significance at 5%

Table 3. Spearman's Rank Correlation Matrix for TC, RWA and SAMA

Variable	TC	RWA	SAMA
TC	1.000		
RWA	.304**	1.000	
SAMA	**.165**	**.273****	**1.000**

** indicate statistical significance at 5%

The correlation coefficients given in Table 2 and Table 3 indicate that there is a significant relationship among the variables, implying that both predictors, teacher clarity and real-world applications, are positively and significantly correlated with students' achievement in modern algebra.

Table 4. Path Analysis for the Path-analytic Model of the Study

Path	Path Constant	Path Coefficient	z-statistic	[95% conf. Interval]
$TC \rightarrow SAMA$	6.904	1.959	2.70**	[.523, 3.395]
RWA →SAMA	2.771	0.824	3.23**	[1.031, 4.291]
$TC \rightarrow RWA$	3.827	.275	3.93*	[.133, .412]
$TC \rightarrow RWA \rightarrow SAMA$	**-1.389**	**1.362 & 2.167**	**1.83 & 2.54****	**[-.093, 2.818] & [.496, 3.837]**

* and ** indicate statistical significance at 1% and 5%, respectively.

The path analysis of the model in Table 4 indicates the following results: First, the utilization of real-world application problems while teaching group theory concepts has a significant positive influence on student achievement in modern algebra. Second, the clear presentation of group theory concepts by the teacher has a significant positive influence on students' achievement in modern algebra. Finally, both teachers' clear presentation of group theory concepts and utilization of real-world applications have a significant positive influence on students' achievement.

Discussion

This study investigated the influence of teacher clarity and the use of real-world application problems on students' achievement in modern algebra, specifically focusing on group theory concepts. Data from 139 undergraduate students who had already completed a modern algebra course were analyzed using Stata14 to test the research hypotheses. Below, we discuss the key findings, implications, and limitations of the study, as well as suggestions for future research.

The Magnitude of Correlation Coefficients for Teacher Clarity and Real-world Applications

The Pearson's correlation among teacher clarity, using real-world applications and students' achievement were statistically significant, although none of these correlation coefficients exceed .4. Normally in populations where the correlation coefficient is already known, the benchmark for correlational analysis is that the variables are strongly correlated if they are close to 1 and weakly correlated if they are below .5. However, some studies reporting Pearson's correlation coefficients between teacher clarity and student achievement were not close to .7. For example, Hines et al. (1985) studied the correlation between teacher clarity and student achievement and found that the Pearson correlation coefficient between the two were .63($p < .05$). Furthermore, Shin et al. (2020) examined the impact of 'hard, peer, and teaching scaffolding framework in inquiry-based learning environments" on students' academic achievement and found that the Pearson's correlation coefficient between teacher scaffolding and students' academic achievement was .291 ($p <$ .001). These previous results imply that the correlation coefficients found in the present study are similar to those of these studies.

The correlation coefficients between teacher clarity, real-world applications and student achievement found in this study also suggest that students who experience an organized and clear presentation of modern algebra concepts using real-world applications will have greater achievement. Furthermore, clear presentation of modern algebra concepts by teachers in the classroom motivate students to attend classes regularly (Blaich et al., 2016), involve in the teaching-learning process (Brewer & Burgess, 2005), engage in classroom activities (Wheeless et al., 2011), and overall foster students' academic engagement (Imlawi et al., 2015). Indeed, students who attend classes regularly, involve in the teaching-learning process, and engage in classroom activities using clear instructional strategies will definitely have greater academic achievement and higher scores in formative and summative assessments in modern algebra courses.

Hypotheses Testing

Hypotheses testing in the model (Figure 1) relating teacher clarity and real-world problem utilization as predictors of student achievement showed the following: First, using real-world applications of group theory concepts during class teaching had statistically significant influence on students' achievement in modern algebra, with z-statistic = 3.23 ($p <$ .05) and 95% confidence interval of [1.031, 4.291], and that confirmed the first research hypothesis (H_1). The results also suggest that incorporating real-world application problems into teaching group theory concepts can lead to an improvement in students' achievement in modern algebra. This supports the idea that contextualizing abstract concepts with real-world examples can help students make connections between theory and practice, thereby enhancing their learning experience. This finding supports the assertion suggested by Butler et al. (2019) that integrating experiential learning activities into the teaching and learning processes leads to continuous improvement and promotes the integration of context, understanding, and experience.

Second, testing the second research hypothesis (H_2) showed that a clear presentation of group theory concepts during class teaching had a statistically significant positive influence on students' achievement in modern algebra, with a z-statistic of 2.70 ($p < .05$) and 95% confidence interval of [.133, .412]. Hence, this finding indicates a significant positive relationship between teacher clarity and student achievement in modern algebra. This is consistent with prior research demonstrating the importance of clear presentation of concepts and well-structured lessons in facilitating students' understanding, regular attendance (Blaich et al., 2016), involvement in class teaching (Brewer & Burgess, 2005), engagement in classroom activities (Wheeless et al., 2011) and performance across various subjects.

Finally, the path analysis testing the third research hypothesis (H_3) showed that the path from TC → RWA → SAMA was statistically significant for the path RWA→SAMA, with z-statistic = 2.54 ($p < .05$), but the path TC→RAWA was not statistically significant. This may imply that considering teacher clarity as a main predictor and real-world applications as a mediating variable influencing student achievement may not hold. However, the overall model analysis and estimation via students' responses to the two measuring items confirmed that both teacher clarity and the utilization of real-world applications while teaching group theory concepts significantly influence students' achievement in modern algebra.

The findings of this study have several important implications for educators and curriculum developers of modern algebra.

Emphasize teacher clarity: Instructors should prioritize clear explanations and well-organized lessons when teaching group theory concepts. This could involve the use of visual aids, analogies, and step-by-step demonstrations to help students grasp complex ideas effectively.

Incorporate real-world applications: Educators should consider integrating real-world application problems into their lessons on group theory concepts to foster deeper understanding and engagement. This approach can help students see the relevance of abstract mathematical concepts in their everyday lives and future careers.

Conclusion

In conclusion, this study examined the influence of teacher clarity and real-world applications on student achievement in group theory concepts. This study demonstrated that the use of real-world applications while teaching group theory concepts and presenting concepts clearly to students is an effective strategy for promoting student learning and achievement in modern algebra. The path analysis results suggest that the use of real-world applications may play a mediating role in influencing student achievement. These findings have important implications for mathematics education, and mathematics educators should consider incorporating these strategies into their teaching practices. The study also showed that both teacher clarity and utilizing real-world applications while teaching group theory concepts had a positive and statistically significant influence on students' achievement. Finally, the study also showed that the hypothetical model was meaningful and was confirmed by the analysis of the collected data.

Recommendations

Based on the hypotheses tested for the hypothetical model using the data collected in this study, the researcher recommends the following. It is important for teachers of modern algebra to be clear when teaching its concepts. A teacher being clear while teaching modern algebra concepts may include being explicit during instruction, clear communication with students, using clear examples, having a well-developed problem-solving guidelines on class assignments, having good preset learning objectives for the concepts, providing detailed answers to students' questions during class teaching, and defining concepts explicitly with well-understood exemplification. In addition, using real-world problems of modern algebra concepts effectively connects the concept and its applications, which in turn, facilitates learning. It is recommended that modern algebra concepts be taught with their applications from daily experience and from other mathematics branches such as cryptography and coding theory.

Limitations

Despite the valuable insights provided by this study, several limitations of this study should be acknowledged. First, the sample size of 139 undergraduate students may not be representative of the entire population of students enrolled in modern algebra courses. Second, this study did not consider other factors that may influence students' achievement in modern algebra, such as prior knowledge, motivation, and learning preferences. Future research could explore the interplay between teacher clarity, real-world application problems, and these additional factors to gain a more comprehensive understanding of the factors that contribute to students' success in modern algebra. Third, this study relied on students' self-reported data, which may have been subject to biases and inaccuracies. Future research could employ more objective measures of teacher clarity and student achievement, such as classroom observations and standardized assessments. The researcher was unable to measure and test the influence of the underlying dimensions of these two predictors due to not having access to those 139 students. Future studies can focus on measuring the influence of the sub-dimensions of teacher clarity (such as explicit instruction, clear communication, and utilizing clear examples) and real-world applied examples of group theory concepts from cryptography and coding theory on students' achievement in modern algebra.

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