

IMPACT OF RUDNICK AND KRULIK PROBLEM SOLVING MODEL ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT AND INTEREST IN MATHEMATICS IN NIGER STATE

¹Kayode Oluwatosin Mary, ¹Aliyu .A. Zakariyya, ²Reuben Abraham Solomon

¹ Department of Science, Ibrahim Badamasi Babangida University

²Department of Physics, Bayero University Kano

Corresponding authors' email: kayodetosin0001@gmail.com

Abstract

Impact of Rudnick and Krulik problem solving model on secondary school students' academic achievement and interest in mathematics in Niger state. A quasi-experimental design involving 100 senior secondary II students from two secondary schools in Lapai, Niger State, Nigeria, was adopted. One school served as the experimental group taught using the Rudnick and Krulik model, while the other control group taught with the conventional lecture method. Data were collected through a structured questionnaire with reliability indices of 0.77. Three hypotheses were tested at the 0.05 significance level using t-test. Results indicated a significant improvement in students' academic performance and interest in mathematics among those taught with the Rudnick and Krulik model compared to the conventional group. No significant gender difference was observed among students exposed to the model. This study concludes that adopting learner-centered, problem-solving instructional strategies can foster greater engagement, motivation and achievement in mathematics.

Keywords: Impact, Rudnick and Krulik Problem Solving Model, Academic Achievement, Interest, Mathematics.

Introduction

Education is the key to unlocking tools used to build and develop a nation and its citizens. It can be formal or informal. According to Nelson Mandela "Education is the most powerful weapon which can be used to change the world". If you want to destroy the future of any nation, no need to wage war with them, defunct their education, they will no longer live on the map of the world. Education plays a crucial role in shaping individuals and contributing to societal development by equipping learners with knowledge, critical thinking, and essential values for personal and professional growth Verma, et al (2023). Education comprises of different disciplines such as science, art, technology, economics, and so on but, mathematics is the heart of all.

According to Cambridge dictionary" Mathematics is the science of numbers, forms, amounts, and their relationships. The role of Mathematics cannot be over emphasize in our day to day activities. In the words of Festus, et al (2015) Mathematics is the foundation and bedrock of economic and technological development in any nation. Despite the importance of Mathematics students still perform low. Statistics as shown that only 38.32% students passed Mathematics and English in West African Examination (WAEC) revealing poor percentage. Many students find mathematics to be abstract, challenging to understand, and monotonous. Grootenboer and Marshman (2016). Low performance has been traced back to many issues but the center of it is student's interest. As a popular proverb says "you can force a horse to the

river but can't force it to drink water". Interest is defined as boost of motivation and guarantees an individual's engagement in content-specific activities. It is an important factor that triggers and promotes learning and is considered essential for academic success. Its presence ensures active and meaningful engagement in classes, which is the key to academic success.

Student engagement refers to active participation in the learning process, where students invest effort and are deeply involved in tasks, encompassing behavioral, emotional, and cognitive dimensions essential for enhancing learning outcomes El-Sabagh, (2021). Engagement plays a pivotal role in the learning process, as Fung, *et al* (2018) demonstrated that students actively engaged in mathematical learning activities tend to achieve greater academic success. Educational psychologists are of the view that learning is much deeper than memorization and information recall. Deep and lasting learning involves understanding, relating ideas and making connections between prior and varied contents. Students often experience fluctuations in their engagement levels when introduced to a new mathematics concept, leading to decreased interest and participation Martin et al. (2015). This has been causing low achievement in Mathematics, signifying that there is an urgent need for solution to enhance and improve students learning using the problem solving model as a strategy for effective teaching and learning to assure the interest of students to live, thereby enhancing the achievement in Mathematics learning.

Problem-Solving Model (PSM) can improve thinking skills and social interaction between students and teachers Panca, et al (2024). The roots of education are bitter, but the fruit is sweet" (Aristotle) and "Teach me and I remember, involve me and I learn" (Benjamin Franklin). This PSM is a step by step method that allows students centered learning not a conventional method (lecture method). Heuristic strategies are generally a tool in problem solving where the steps to solve the problem are sequential and have various types Vongyai and Noparit (2019). Heuristic strategies are innovative learning approaches in which students develop self-reliance and self-direction.

Heuristics is a strategy that has rules in certain situations and is used as problem-solving technique so that complex problems can be simpler and limit the number of possible answers so that they are easier to manage (Lalzawmliana, 2022). The application of Heuristic strategies in learning can be seen from the steps for solving problems as explained by Polya, Rosyada and Retnawati (2021) that heuristic strategies in learning consist of four stages, namely: 1) wondering/reading the problem, 2) designing/exploring and selecting a strategy, 3) investigating solving, and 4) discovering looking back. While Krulik & Rudnick explains Heuristic strategies in various types including: 1) read and think, 2) explore and plan, 3) select a strategy, 4) find and answer, 5) reflect and extend. However, the way mathematics teaching and learning activities are presented to students can make them hate or like the lesson (Iwuanyanwu, 2021).

Statement of the Problem

Research reports (Festus et.al 2015 & Osuafor et.al 2017) have clearly shown that senior secondary school students perform woefully in mathematics, it also indicated that the process of silly errors which students makes while solving mathematics problems have contributed to

students poor achievements in Mathematics. These poor performance contributes to their lack of interest for mathematics learning. Furthermore, consistence poor achievement in mathematics subject has impacted negatively on the Nigerian tertiary education system. Most of secondary schools" graduates fails to meet up with the minimum performance standards in mathematics required for successful completion and as such tends to impact negatively on the country's academics standard, human resources and whereby creeping it economics development. Due to the aforementioned problem, there is a necessity to use Rudnick and Krulik problem solving model as a strategy for effective teaching and learning to assure the interest of students to live, thereby enhancing the achievement in mathematics learning.

Methodology

The study adopted a quasi-experimental design, using the pre-test, post-test, control group design. Two groups were involved an experimental group and a control group. The experimental group was taught using the Rudnick and Krulik Problem-Solving Model (RKPSM), while the control group was taught using the lecture method. This design was chosen because it allows for comparison between groups and helps control extraneous variables. The population comprised all Senior Secondary School Two (SSS 2) mathematics students in Lapai Local Government Area, Niger State. These students were chosen because the concept of Quadratic Equations is included in their mathematics curriculum.

A multistage sampling technique was used. In the first stage, schools were grouped into clusters based on their location (urban and rural). In the second stage, two schools were selected using purposive sampling based on comparable facilities and teacher qualifications. Finally, one school was randomly assigned as the experimental group and the other as the control group using a coin toss. Three main instruments were used; the Mathematics Achievement Test (MAT) for both pre-test and post-test. The MAT consisted of 20 multiple-choice items drawn from the SS2 mathematics curriculum on the topics of perfect squares and quadratic equations. The test was administered as both pre-test and post-test to assess students' achievement before and after treatment, Students' Interest Questionnaire (SIQ) to measure students' interest in mathematics. It consist of 20 questions using Likert five-point scale method response and Instructional Lesson Plans for both experimental and control groups. The questions used as instruments were subjected to face validation by three experts, two in mathematics education and one in measurement and evaluation, from the Department of Science Education, Ibrahim Badamasi Babangida University, Lapai. Necessary modifications were made based on their feedback.

The study lasted for four weeks. At first week a Pre-test was administered to both groups to determine their baseline achievement and interest levels. After which, teaching and learning commenced properly, the experimental group received instruction using RKPSM, while the control group was taught with the lecture method. The treatment lasted two weeks (six lessons). Then at week four a Post-test was administered to both groups immediately after treatment to measure the effect of the instructional method. Data collected were analyzed using descriptive and inferential statistics: Mean and Standard Deviation were used to answer research questions on students' achievement and interest. T-test was employed to test the hypotheses at a 0.05

level of significance to determine whether there was a statistically significant difference between the experimental and control groups.

Results

Research Question 1: Is there any difference in performance between students taught mathematics using the Rudnick and Krulik Problem Solving Method and those taught using the conventional method?

Table 1: Mean and standard deviation of pretest for experimental and control group.

Groups	Number	Mean	Standard deviation	Mean difference
Experimental (O ₁)	50	2.8200	1.6866	-0.3200
Control (O ₁)	50	2.5000	1.5152	

Table 1 revealed the pre-test mean and standard deviation scores of students in the experimental group were 2.8200 and 1.6866, respectively, while those in the control group were 2.5000 and 1.5152. The mean difference is (-0.3200). Both groups were comparable before the treatment.

Table 2: Mean and standard deviation of post-test for experimental and control group

Groups	Number	Mean	Standard deviation	Mean difference
Experimental (O ₂)	50	7.4800	1.1993	2.5400
Control (O ₂)	50	4.9400	1.1141	

The post-test results show mean and standard deviation values of 7.4800 and 1.1993 for the experimental group, and 4.9400 and 1.1141 for the control group. The mean difference (2.5400) indicates that students exposed to the Rudnick and Krulik Problem Solving Model performed better than those taught using the conventional approach. In order to establish if the difference is statistically significant, inferential statistics was used to test the null hypothesis. Hypothesis One (H₀₁): There is no significant difference in the performance of students exposed to the Rudnick and Krulik Problem Solving Method and those not exposed.

Table 3: T-test Comparison of Pre-test for Experimental and Control Group

Groups	No.	Mean	STD	DF	T-Cal	T-Crit	P-value
Experimental (O ₁)	50	2.8200	1.6866				
				98	-0.9980	±1.984	0.3207
Control (O ₁)	50	2.5000	1.5152				

The t-test results shows that there was no significant difference in the pre-test mean scores between the two groups at 95% confidence level ($t_{(98)} = -0.9980 < 1.984, p > 0.05$). We fail to reject the null hypothesis. This implies that both groups were statistically equivalent before the experiment.

Table 4: T-test Comparison of Post-test for Experimental and Control Groups

Groups	Mean	No.	STD	DF	T-Cal	T-Crit	P-value
Experimental (O ₂)	50	7.4800	1.1993				
				98	10.9720	±1.984	<0.05
Control (O ₂)	50	4.9400	1.1141				

Since t-calculated (10.9720) > t-critical (1.984), the null hypothesis is rejected. This indicates a significant difference in performance between the two groups, with students in the experimental group achieving higher scores.

Research Question 2: Is there a change in interest between students taught using the Rudnick and Krulik Problem Solving Method and those taught using the conventional method?

Table 5: Mean Rank and Sum of Ranks on Interest for Experimental and Control Groups

Groups	Number	Mean rank	Sum of ranks
Experimental	50	55.5	2775
Control	50	30.5	1275

Students in the experimental group had higher mean and sum of ranks, suggesting increased interest in mathematics after exposure to the Rudnick and Krulik Problem Solving Method.

Hypothesis Two (H₀₂): There is no significant change in the interest of students taught mathematics using the Rudnick and Krulik Problem Solving Method and those taught using the conventional method.

Table 6: Mann-Whitney U-Test on Interest Levels for Experimental and Control Groups

Groups	No.	Mean rank	Sum of ranks	U-cal	U-critical	Z	P	Remark
Experimental	50	55.5	2775					
				147.00	75	-7.7166	0.001	sig
Control	50	30.5	1275					

Since U-calculated (147.00) > U-critical (75) at p = 0.001, the null hypothesis is rejected. Therefore, there is a significant change in students' interest when taught using the Rudnick and Krulik Problem Solving Method.

Research Question 3: Is there any gender difference among students taught mathematics using the Rudnick and Krulik Problem Solving Method?

Table 7: Mean and Standard Deviation of Post-Test Scores by Gender (Experimental Group)

Experimental group	No.	Mean	STD	Mean difference
Female	37	6.4865	1.2828	
				-0.2827
Male	13	6.7692	1.2352	

The results show that Male students (Mean = 6.7692) slightly outperformed their Female counterparts (Mean = 6.4865), but the difference is marginal.

Hypothesis Three (H₀₃): There is no significant influence of gender on students taught mathematics using the Rudnick and Krulik Problem Solving Method.

Table 8: t-Test Comparison of Post-Test Scores by Gender (Experimental Group)

Experimental group	Number	Mean	STD	DF	T-Cal	T-Crit	P-value
Female	37	6.4865	1.2828	48	-0.6899	±2.01	0.4936
Male	13	6.7692	1.2352				

Since t-calculated (-0.6899) < t-critical (+2.01), the null hypothesis is accepted. This indicates no significant gender difference in mathematics achievement when taught using the Rudnick and Krulik model.

Discussion of Findings

The findings indicate that the Rudnick and Krulik Problem Solving Method significantly improves students’ achievement and interest in mathematics. The experimental group outperformed the control group, aligning with Samuel & Obikizie (2020), who reported that students taught algebra using Polya George’s Problem Solving Model performed better than those taught conventionally. Jufriadif *et al* (2025) also discovered that one method that can improve student’s problem solving skills is Rudnick and Krulik indicator. Furthermore, the study revealed that the Rudnick and Krulik Problem Solving Method enhanced students’ interest in mathematics. This agrees with Ado (2018), who found that participation in mathematics clubs improved students’ interest and performance in mathematics.

Finally, results from the gender analysis showed no significant differences in performance between male and female students. This aligns with Osuafor and Orji (2017), who found no significant gender difference in achievement when problem-solving techniques were employed in algebra instruction. This also in accordance with Dawngliani, et al (2019) research finding which revealed that no significant difference were found in relation to gender and mathematical problem solving abilities of learners. Overall, the findings suggest that the Rudnick and Krulik problem solving model is effective in improving students’ mathematics performance and interest, irrespective of gender.

Conclusion

The findings of this study have provided empirical evidence that the Rudnick and Krulik problem solving model significantly enhances students’ achievement and interest in mathematics compared to the conventional method of teaching. The experimental group consistently outperformed the control group in both performance and motivational indices, demonstrating the pedagogical strength of this approach in promoting active learning and deep conceptual understanding.

Furthermore, the study established that the use of the Rudnick and Krulik model not only improved students’ academic outcomes but also stimulated their enthusiasm toward mathematics learning. This suggests that when students are engaged through structured problem-solving strategies, they become more confident, inquisitive, and motivated to explore mathematical ideas.

In addition, the analysis of gender differences revealed no statistically significant disparity in performance between male and female students. This indicates that the Rudnick and Krulik problem solving method is gender-inclusive and equally effective for all learners regardless of sex.

Recommendations

The adoption of the Rudnick and Krulik problem solving model in mathematics classrooms offers a viable and innovative approach to improving students' learning outcomes and interest. It is therefore recommended that mathematics teachers, curriculum planners, and educational policymakers integrate this method into instructional practices at the secondary school level. Doing so could foster a more engaging, equitable, and performance-driven mathematics learning environment that better equips students with critical thinking and problem-solving skills necessary for academic and real-life applications.

References

- Ado, I. B. (2018). Advance organizer: A Panacea For Students Achievement and Retention for Functional Teaching of Mathematics. *Journal of Education*, 10(1), 64-72.
- Dawngliani, M., Ralte, L., & Fanai, L. (2019). A Study on Problem Solving Ability of Government Secondary School Students in Aizawl City with Reference to Gender. . *International Journal of Peace, Education and Development*, 7, 115--119.
- Dictionary, C. (n.d.). *Mathematics*. Retrieved December 18 , 2025, from <https://dictionary.cambridge.org/dictionary/english/mathematics>.
- El-Sabagh, H. A. (2021). Adaptive E-Learning Environment Based on Learning Styles and Its Impact on Development Students' Engagement. *International Journal of Educational Technology in Higher Education*, 18(1). doi:10.1186/s41239-021-002
- Festus, A. B., & Seraphina, K. M. (2015). Effects Of Emotional Intelligence Skills Acquisition On Students' Achievement In Senior Secondary School Geometry In Keffi Education Zone, Nasarawa State, Nigeria . *Asian Journal of Education and E-learning*, 3(4).
- Fung, F., Tan, C. Y., & Chen, G. (2018). Student Engagement and Mathematics Achievement: Unraveling Main and Interactive Effects. *Psychology in the Schools*, 7(55), 815–831. doi:org/10.1002/pits.22139.
- Grootenboer, P. J., & Marshman, M. (2016). The Affective Domain, Mathematics, and Mathematics Education. In *Mathematics, Affect and Learning Springer*, 13-33. doi:10.1007/978-981-287-679-9_2.
- Iwuanyanwu, P. N. (2021). Contemporary Problems of Teaching and Learning in Mathematics Education. *Mathematics Teaching Research Journal*. Retrieved from <https://ed.gov/?id=EJ1383115>.
- Jufriadif, L. S., Addini, Y., & Khadijah, K. (2025). Enhancing Problem-Solving Reliability with Expert Systems and Krulik-Rudnick Indicators. *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, 9(2), 357-363. doi:10.29207/resti.v9i2.6333.

- Lalzawmliana, H. C. (2022). A comparative study on problem solving ability and academic achievement motivation of secondary school students of Lai Autonomous District Council (LADC) and Chakma Autonomous District Council (CADC) in Mizoram . *Unpublished master's thesis, Mizoram University.*
- Martin, A. J., Papworth, B., Ginns, P., Malmberg, L. E., Collie, R. J., & Calvo, R. A. (2015). Real-Time Motivation and Engagement During a Month at School: Every Moment of Every Day for Every Student Matters. *Learning and Individual Differences, 38*, 26–35. doi:org/10.1016/j.lindif.2015.01.014.
- Osuafor, A. M., & Orji, C. J. (2017). Effect of problem solving technique on secondary school students' academic achievement in selected topics in algebra. *Elixir Educational Technology, 107*(17), 47250-47253.
- Panca, P. R., Hidayatul, B. N., & Puspa, M. A. (2024). Problem Solving Method In Improving Students' Critical Thinking Abilities In Social Studies Learning. *International Journal of Educational Research, 1*(3), 1-10. doi:10.62951/ijer.v1i3.41
- Rosyada, M. N., & Retnawati, H. (2021). Challenges of mathematics learning with heuristic strategies. *Al-Jabar: Journal of Education*. Retrieved from <https://ejournal.radenintan.ac.id/index.php/al>
- Samuel, N. N., & Obikizie, M. C. (2020). Effect of contextual Teaching - Learning Approach on Student's Achievement in Chemistry in Secondary Schools in Anambra State, Nigeria. *International Journal of innovative Research & Development, 9*(12), 97-101. doi:org/10.24940/ijird/2020/v9/i12/DEC20028
- Verma, A., Verma, K., Yadav, V. R., & Doharey, R. K. (2023). Education: Meaning, definition & Types. In *Agriculture Extension Education . S. R. Scientific Publication*, 1-6.
- Vongyai, A., & Noparit, T. (2019). using heuristic strategies to promote mathematics problem solving ability of grade 10 students. *people: International Journal of Social Sciences, 5*(1), 952-968. doi:10.20319/pijss.2019.51.952968