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A Focused Analysis of Common Difficulties Faced by Class IX Students in Algebra

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Abstract
Students' Mathematics performance in schools is one of the major concerns in Mathematics education. Students face several difficulties while learning mathematics in their school years. Among the sub-branches of Mathematics, students are found to have greater difficulties in algebra, which moves beyond basic mathematics and prepares for higher mathematics. This study is conducted with an objective to find out the specific difficulties faced by secondary school students while solving algebraic problems. For this, a descriptive survey method is employed. Samples are randomly selected from 4 CBSE schools in Bhubaneswar city of Odisha. A self-developed criterion-referenced test is administered based on the NCERT class IX mathematics textbook. The error analysis technique is used to analyze the data. Among the specific difficulties solving word problems using the variables, factorization of the polynomials using the identity, finding the degree of polynomials, applying the identities to solve algebraic problems, finding the zeros of the polynomials, factorizing the quadratic polynomials are found to be some of the areas where maximum number of students struggle. Few students face difficulties even with the simplest of the problems of algebra like finding the solutions of a linear equation. The difficulties faced by students and the types of errors with examples are detailed in the article. Major findings with discussion along with their implications for students, teachers and also for teacher education programs are highlighted. Thus, it helps to gain a better understanding into learning of algebra and try out possible solutions for students while solving algebraic expressions.

Keywords: Mathematics, Secondary School Students, Specific Difficulties, Algebra, Class IX

1. INTRODUCTION

Mathematics is one of the most important subjects for the everyday life of human beings. Without the basic understanding of it, we can say nothing is possible. Mathematics has been accepted as an important component of formal education from the ancient period to the present day (Kandeel, 2019). Students learn mathematics well only when they construct their mathematical understanding and this understanding requires them to examine, represent, transform, solve, apply, prove, and communicate. The main goal of mathematics education is to develop children's abilities for mathematization (NCF, 2005). But in fact, difficulties make mathematics less desirable, feared, and boring for students. This can be seen from the students' poor results in mathematics. For this, educationists as well as the state are facing the challenges with the problems of failure in board examinations in mathematics.

The mathematical concept is a mental construct. These concepts are hierarchically related. The process of concept acquisition involves the process of associating understanding gained from real or partly real experiences with the

words. Mathematical symbols and words play an important role in the understanding of Mathematics. The child may not be able to communicate his thoughts and his concepts, not due to a lack of understanding of concepts but due to a lack of vocabulary in mathematics.

The main areas of mathematics are arithmetic, algebra, and geometry. Arithmetic involves numbers and basic mathematical operations. Geometry deals with figures and their properties. But algebra deals with both the numbers and the alphabet. In algebra, the numbers are known as the constants and the alphabets are called variables. Algebra is known to be a core subject in school mathematics and also a gateway to advanced mathematics. So, to achieve more in mathematics, one must have a clear understanding of algebra. As it applies mathematical operations using numbers and alphabets, it is more abstract in nature. So, more abstract thinking is needed to deal with algebra.

Various studies mentioned the difficulties of students in learning algebra in the process of mathematizing everyday sentences into mathematical forms, understanding algebraic equations, basic mathematical operations, and understanding the meaning of symbols equal to and the meaning of variables (Jupri et al., 2014). Stacey & Chick (2004) also said algebraic knowledge and skills are relevant in daily and professional life either directly or as a prerequisite. Though it is quite necessary to learn algebra, many researchers have found its difficultness to learn and to teach as well (Watson, 1990; Stacey & Mac, 1999). The language of mathematics is unique and this often leads to challenges for students in understanding it. One of the main difficulties experienced by students in completing word problems related to algebra are turning problems into mathematical symbolic problems &formulating equations and vice-versa (Jupri & Drijvers, 2016). So, translating the words to algebraic expression and vice-versa is a major concern for students. Another difficulty faced by secondary school students while solving algebraic equations. Those students with an incomplete understanding of the negative sign are more likely to use incorrect strategies when solving algebraic equations (Booth & Koedinger, 2008). Similarly, there are various areas where students face problems. In general, algebra becomes a problem for students (Bell, 1995).

2. RESEARCH QUESTION AND OBJECTIVE

Based on the above, a question that needs to be answered is “What are the specific difficulties faced by class IX students while solving algebraic problems?” To answer this question, an objective is framed as “To identify the specific difficulties faced by class IX students while solving algebraic problems.”

3. METHODS

The intention of this study is to know the specific problems that are creating difficulties for the secondary school students while solving algebraic problems. So, for this, Descriptive Survey Method is used choosing the city of Bhubaneswar to gather the data.

4. POPULATION AND SAMPLE OF THE STUDY

Since the current study is based on the secondary school students and includes both government and private schools, the population is selected from class IX students of both government and private schools in Bhubaneswar. For the current study, a total of 198 samples are selected from 2 government and 2 private schools. The study is delimited to schools that follow the CBSE curriculum.

5. TOOLS USED

A self-made Criterion-Referenced Test is constructed based on the NCERT class IX textbook. This tool included seven criteria under which the secondary school students were tested.

Sl. No.	Criterion
1	Solution of linear equation
2	Factorization of quadratic polynomial
3	Finding the zeros of the polynomials
4	Applying the identities
5	Finding the degree of polynomials

6	Factorization using identity
7	Solving word problems

This test is constructed to provide a clear picture of the difficulties those are faced by the secondary school students while solving the algebraic problems.

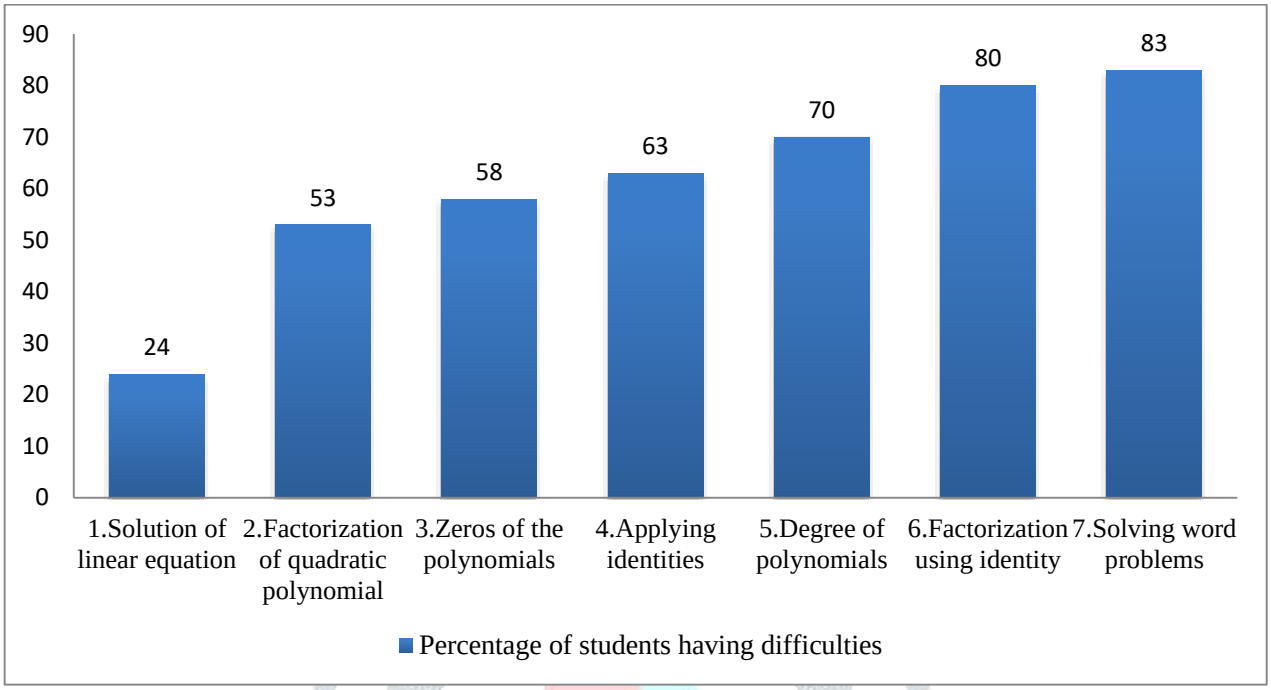
6. DATA ANALYSIS

After the collection of data by Criterion-Referenced Test, the answer sheets of the students are checked thoroughly. The errors committed by the secondary school students for each criterion are marked out from their answer sheets. Then, the errors are analyzed to identify the difficulties faced by the secondary school students and the possible reasons for the difficulties are discussed. The following table gives the details.

Sl. No.	Criterion	Example of Errors Committed	Possible Reasons
1	Solution of linear equation	Q. How many solutions are possible in a linear equation in two variables? A. 1	Understanding the phrase linear equation in one variable and two variables.
2	Factorization of quadratic polynomial	Q. Factorize $3 - 8x + 4x^2$ A. $3 - 3x - 5x + 4x^2$ $= 3(1 - x) - x(5 - 4x)$	No clear understanding of splitting the middle term while factorizing
3	Finding the zeros of the polynomials	Q. How many zeros a quadratic polynomial has? A. 1	Understanding the concept of zeros of the polynomials
4	Applying the identities	Q. Calculate $(8)^3 + (-15)^3 + (7)^3$ by using suitable identity. A. $(8)^3 + (-15)^3 + (7)^3 - 3 \times 8 \times (-15) \times 7$	Choosing the right identity to solve this problem
5	Finding the degree of polynomials	Q. The degree of a non-zero constant polynomial is ___. A. 2	No clear concept of the degree of polynomials
6	Factorization using identity	Q. Factorize $64p^3 - 8q^3 - r^3 - 24pqr$ using suitable identity. A. $(4p - 2q - r)^3 + (-8pq + 2qr - 4pr)$	Choosing the proper identity to factorize the polynomial
7	Solving word problems	Q. An auto charges ₹15 for the first kilometer and ₹8 each for every subsequent kilometer. For a distance x km, an amount of ₹y is paid. Write the linear equation for the above information. A. $15x + 8y = 0$	Understanding the problem and choosing the variables accordingly to solve this problem.

7. MAJOR FINDINGS

After analyzing the collected data, it is shown that the students are facing difficulties with the above-set criteria. The below chart shows the percentage of students having difficulties with each set criterion.



*decimal numbers are rounded off to their nearest whole numbers

Algebra is considered one of the difficult areas in mathematics. Its abstract nature makes it more difficult to learn by the students. Mathematics has its own language. Often, students make mistakes in understanding the mathematical language. Word problems use the unique language of mathematics. The highest percentage of students are facing difficulties in solving word problems using the variables. For them, difficulties arise in understanding the word problems and then converting them into algebraic expressions. This could be due to a misunderstanding of the mathematical language. In mathematics, factorization is the product of its irreducible factors. Many students are facing difficulties while factoring the polynomials using the identity. Identities make the factorization easier. This difficulty among students may be due to memorizing the identity. One can easily find the degree of a polynomial by looking at the highest power of the variable. Still, the students are facing problems in finding the degree of polynomials. This could be due to an ambiguous understanding of the concept of the degree of polynomials. The students could not interpret concepts and clarify the elements of algebraic forms related to variables, coefficients, and constants, and could not operate and simplify algebraic forms (Noto et al., 2020; Muchoko et al., 2019).

Identities play an important role in solving mathematical problems. It is found that more than half of the students face difficulties in applying the proper identity to solve a mathematical problem. The zero of a polynomial means finding the value of the variable for which the value of the polynomial becomes zero. Still, students are unable to find the zeros of the polynomials. The students are also facing difficulties in factoring the quadratic polynomials. While factorizing the quadratic polynomials, they face problems in splitting the middle term, which is the base of factorization. Apart from these, students also face problems in understanding the polynomials; sometimes, they can't even organize the polynomials. The least difficulties are faced in finding the solution of linear equations. This may be due to the easier form of algebraic expressions. In algebra, the polynomials are only the expressions, whereas equations are conditions on a variable having an equal sign. Here, the students are showing great confusion between algebraic polynomials and equations.

8. DISCUSSION

The study revealed that most secondary school students are facing difficulties while solving algebraic problems. Algebra uses letters for variables and numbers for constants. The greatest number of students faced problems in understanding the polynomials and writing the constants and variables in their corresponding places. The arising difficulties in algebra may be due to its unique language. So, the students need to incorporate mathematical language teaching in the early grades at school (Rao et. al., 2017). The students are unable to understand the numerical relationship between the two quantities in algebraic terms due to poor understanding of the arithmetic-algebraic

connection in the problem (Egodawatte, 2009). Pramesti and Retnawati (2019) revealed that the cause of students' errors in algebra includes at least three things, namely understanding the problem, understanding the meaning of variables, and operating the algebraic form. Solving word problems is one of the most challenging tasks for students. This difficulty is highly affected by the language used in algebra (Tiwari & Fatima, 2019). Apart from language, there are certain other factors, such as problems in reading text or questions, misinterpreting the problem, and the students having difficulty in understanding the problem, so they can't interpret it into symbol form (Novriani & Surya, 2017). Identities play a major role in mathematics, in which students face problems. From the study, it is found that factorization is comparatively easy for the students, but when it is instructed to apply the suitable identity to factorize, then it becomes more difficult for them. The students could not realise that they should factorize by utilizing identities, a lack of knowledge in the fundamentals of mathematics (Yahya & Shahrill, 2015; Burhanzade and Aygör, 2015). Yasoda (2003) has also found that students are facing problems relating to identity in understanding, remembering, deriving, and selecting suitable solutions while solving the problems. Overall, the difficulties in learning Algebra are due to the negative attitudes of students toward solving algebraic problems (Julius et al., 2018).

9. CONCLUSION

Secondary education plays an important role in a country's educational system. It is intermediate between primary and higher education. Primary education provides the basics for survival, whereas secondary education helps individuals to become active members of a complex society. Secondary education aims to develop a scientific attitude of mind to think objectively and to inculcate the qualities necessary for living harmoniously and efficiently with one's fellowmen (Secondary Education Commission, 1952-53). For this, the role of Mathematics is highly appreciated.

Though mathematics is essential for harmonious development, some difficulties make it devalued by the students. As algebra is one of the branches of mathematics, this study tries to reveal various difficulties that have been faced by secondary school students while solving algebraic problems at the secondary level. The study found that some of the difficulties faced by secondary school students in algebra are solving word problems, application of suitable identities, understanding polynomial factorization by using identities, etc. It is because of the lack of interest, misinterpretation of the questions, improper way of teaching, and lack of individual attention.

To conclude, the teachers must be aware of the students' difficulties in understanding the concepts, content, or word problems with mathematical signs and symbols. Innovative teacher education programs that sensitize prospective teachers to the reasons for difficulties faced by students at the initial stage of learning need to be developed. Such an approach to teacher education goes a long way in creating sensitive teachers for the larger system, thereby addressing the crucial needs of students. Such teachers would surely provide special attention to rectify the problems by understanding the reasons behind them. To make mathematics education more effective at the secondary level, the learning should be made purposeful and enjoyable. Teachers who are well aware of the challenges work towards designing simple strategies to solve problems, making them independent problem solvers.

10. EDUCATIONAL IMPLICATIONS

The above study seems to have important implications for understanding the difficulties encountered by the students which are briefly described below.

- **For Teacher Education Programs**

  The Department of Education in each university plays a pivotal role in running teacher education programs. It continuously provides training to both pre-service and in-service teachers. It is hence required to know the problematic areas of the students so that strategies to teach algebra can be incorporated during such programs. Self-learning material can be developed for teachers and students to minimize student difficulties in learning algebra.

➢ **For Schools**

Students' learning in Mathematics with deeper understanding may not take place in the classroom due to certain specific reasons. After knowing these reasons, schools should plan and prepare a well-structured classroom with the availability of resource materials to support student learning.

➢ **For Teachers**

Students' in-depth learning is highly concerned with teachers. The findings of this study will aware the teachers about the difficult areas as well as specific difficulties faced by the students. Accordingly, teachers can develop the knowledge of subject matter, and pedagogical content knowledge during the teaching-learning process to address these difficulties.

➢ **For Students**

Like the teachers, the findings are also useful for students. They should focus on these difficulties to gain a better understanding and in-depth knowledge in concerned areas by going through special learning materials, working on worksheets for practice, and also making an additional effort to grasp the concept by interacting with teachers and peers.

References

Bell, A. (1995). Purpose in school algebra. *The Journal of Mathematical Behavior*, 14(1), 41–73.

Booth, J. L., & Koedinger, K. R. (2008). Key misconceptions in algebraic problem solving. In B. C. Love, K. McRae, & V. M. Sloutsky (Eds.), Proceedings of the 30th Annual Cognitive Science Society, 571–576. Austin, TX: Cognitive Science Society.

Burhanzadea. H., & Aygör, N. (2015). Difficulties that students face during factorization questions. *Procedia - Social and Behavioral Sciences*, 191, 859–864.

Egodawatte, G. (2009). Is Algebra Really Difficult for All Students? *Acta Didactica Napocensia*, 2(4), 101-106.

Julius, E., Abdullah, A. H. & Suhairom, N. (2018). Attitude of Students towards Solving Problems in Algebra: A Review of Nigeria Secondary Schools. *IOSR Journal of Research & Method in Education*, 8(1), 26-31.

Jupri, A. & Drijvers, P. (2016). Student Difficulties in Mathematizing Word Problems in Algebra. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(9), 2481-2502.

Jupri, A., Drijvers, P. & van den Heuvel-Panhuizen, M. (2014). Difficulties in initial algebra learning in Indonesia. *Math. Educ. Res. J.* 26, 683–710

Kandeel, R. A. A. (2019). Students' Academic Difficulties in Learning a Statistics and Probability Course: The Instructors' View. *Journal of Education and Practice*, 10(9), 43-52.

MHRD (1952-53). Secondary Education Commission Report, Ministry of Human Resource Development, Government of India, New Delhi.

Muchoko, C., Jupri, A. & Prabawanto. S. (2019). Algebraic visualization difficulties of students in junior high school. *Journal of Physics: Conf. Series*, 1157.

NCERT (2005). National Curriculum Framework (NCF) 2005, National Council for Educational Research and Training, New Delhi.

Noto, M. S., Pramuditya, S. A., & Handayani, V. D. (2020). Exploration of learning obstacle based on mathematical understanding of algebra in junior high school. *Eduma: Mathematics Education Learning and Teaching*, 9(1), 14 - 20.

Novriani, M. R., Surya, E. (2017). Analysis of student difficulties in mathematics problem solving ability. *International Journal of Sciences: Basic and Applied Research*, 33(3), 63-75.

Pramesti, T. I., & Retnawati, H. (2019). Difficulties in learning algebra: An analysis of students' errors. *Journal of Physics*, 1320, 1-8.

Rao, P. K. S., Ramaa, S., & Gowramma, I. P. (2017). Does Knowledge of Mathematical Language Play a Role in Mathematical Ability? – A Preliminary Study. *Journal of All India Association for Educational Research*, 29(2), 83-100.

Stacey, K., & Chick, H. (2004). Solving the problem with algebra. In Stacey, K., Chick, H., Kendal, M. (Ed.), The Future of the Teaching and Learning of Algebra The 12th ICMI Study (pp. 1-20). New ICMI Study Series, vol 8. Springer, Dordrecht.

Stacey, K., & Mac, G. M. (1999). Taking the algebraic thinking out of algebra. *Mathematics Education Research Journal*, 1, 24- 38.

Tiwari, C. & Fatima, R. (2019). Secondary School Students' Misconceptions in Algebra Concepts. *Mahatma Gandhi Central University Journal of Social Sciences*, 1(1), 22-33.

Watson, J. (1990). Research for teaching. Learning and teaching algebra. *Australian Mathematics Teacher*, 46(3), 12–14.

Yahya, N. & Shahrill, M. (2015). The strategies used in solving algebra by secondary school repeating students. *Procedia - Social and Behavioral Sciences*, 186, 1192–1200.

Yasoda, R. (2003). *An investigation into the problems relating to teaching - learning mathematics at secondary level* (Doctoral thesis, Department of Education, Sri Venkateswara University, Tirupati, Andhra Pradesh).