Mathematics Teachers' Perceptions Towards Students' Role in Committing Mathematical Errors

Mukunda Prakash Kshetree, PhD
(Associate Professor)
Department of Mathematics Education, MR Campus
Tribhuvan University, Kathmandu, Nepal

Abstract

The main area of investigation was mathematics teachers' perceptions towards role of students themselves in making errors while learning mathematics. Thus, this research study has explored, collected, analyzed and presented the opinions of mathematics teachers in regard to their students' mathematical errors. This area of study consisted of seven major themes. The study has mainly followed a qualitative research design. As the data collection tools, it has used guidelines for interview and focus group discussion (FGD), and a set of questionnaire for survey research. The study has used all the primary information and data. The qualitative information was coded as per the main themes of investigation and then they were critically judged, analyzed and interpreted. The information was also supplemented and strengthened through the data obtained from the survey research. At the end, the findings of the study were triangulated with reference to previous research studies and theories.

Keywords - *Mathematics learning and errors, teachers' perceptions, constructivism, student' role in learning*

I. INTRODUCTION

The teachers build up their knowledge and perception towards students' errors through reflecting own student life, teaching experience, professional trainings, and different contexts faced while teaching students. Those perceptions are closely linked to teachers' strategies while coping with challenges raised by students' errors in their daily classroom teaching/learning (T/L) practices. Teachers' perceptions shape up students' T/L environment and influence student motivation and achievement as claimed by Hill, Rowan and Bass (2005). Thus, it is understood as latent factor which is reflected on teachers' specific instructional practices. Yet today, as in the past, many students struggle with mathematics and remained under achieved as they continually confront obstacles caused by errors. In order to break this pattern it is imperative that the teachers should create the environment of error-tolerant classroom for their better understanding, discussing and treating them. Thus, investigation of mathematics teachers' perceptions has become a significant endeavor in T/L mathematics.

Students make errors for many reasons where some errors happen because students have not taken sufficient time or care; others are the result of consistent, alternative interpretations of mathematical ideas that arise from learners' attempts to create meaning. It shows that making errors is a learning process so, teachers should not be afraid of them. In fact, the mistakes are often the best teachers. This indicates the students' life having experience of dealing with numerous errors that can have positive effects. The errors are like T/L tools which the students use to refine and craft their learning strategies. A good error will reveal the state of the student's problem to the teacher; that is, his/her areas of weakness whether he/she needs a help in specific area. Thus, with the feedback received from errors, a classroom teacher can either go ahead or revise his work. So, it needs to examine teachers' perceptions towards errors.

Actually, children's mastery in mathematical concepts and skills depends upon the negligible errors that they commit. Teachers' right perceptions and knowledge of error analysis make the learning mathematics meaningful. But, for this, the mathematics teachers should have apparent knowledge towards students' errors. Further, they should entertain students' errors and orient them in student-friendly environment. The orientation of errors includes handling errors with positive attitude, proper communication among teachers and students, no risk for students to make errors, content wise identification of errors, anticipation of errors and learning from them. But problem is that we don't have such a formal system of error analysis and make a specific plan and strategies to address them. Though it is a most important pedagogical part of learning, such a system neither can be seen in any course of pedagogy nor teacher training programs. In this ground reality, this study was envisioned to fill up such a gap by exploring teachers' perception towards the role of students in mathematical errors.

II. STATEMENT OF THE PROBLEM

Teachers think that learning is an individual task and responsibility of student. Most of the mathematics teachers use lecture method for teaching and let their students sit by themselves with papers, workbooks and pencils

to struggle independently to solve the mathematical problems. This learning process can be boring, lonely and frustrating. Therefore, it is not surprising that most of the students, trapped in errors, and lost their interest in learning mathematics. Even a single error may prevent the progress and accomplishment, so we cannot say what happens if a child has a variety of errors. Obviously, the more errors a child has the more likely s/he is to experience failure in examinations which the teachers should take seriously.

In our classroom T/L practice, teachers dispense the information only and make the students fall in fear of failure, teach for tests only, make T/L less exciting, follow teacher-centric method, don't care their diversified learning paces, full of rote learning, mechanical-drill-and-practice, one-size-fits-all, talk-and-talk then get fade up etc. (Kshetree, 2013). Teachers are furious when they see students' errors and deal the errors with superficial correction. Because of which our T/L practice has hampered students' creativity, progress, and learning mathematics meaningfully.

So, the teachers should have knowledge of identifying and addressing students' errors in order to draw the attention of the students and guide them in the areas of known difficulties. Further they need to have a positive perception and behavior so that students' errors could be practiced in classroom without any threat and risk for their systematic remediation. But, it is obvious that our school level T/L practices have not been following this mechanism. Thus, this study has aimed to uncover teachers' real perceptions towards the role of students in making errors in their mathematical tasks.

III. OBJECTIVE OF THE STUDY

This study was based on the argument that teachers' perceptions and understandings over students' errors play a crucial role in students' learning process of mathematics. Thus, this study had set forth a main objective as to appraise mathematics teachers' perceptions towards the role of students in committing mathematical errors.

IV. RESEARCH QUESTIONS

Based on the objective of this study as stated above, the major research questions set forth were as follows.

1. How are students' learning preparations?
2. How is students' attitude towards mathematics?
3. How is students' psychological situation while learning mathematics?
4. What are the capabilities of students to learn mathematics?
5. What are students' wrong perceptions?
6. How is the situation of violating mathematical rules?
7. How do students interpret and generalize the mathematical concepts?

V. REVIEW OF LITERATURE

The task of literature review is supposed to be a backbone of the study as it opens the fast track in the research work without any duplication. Actually, it gives the idea to develop each and every section of the research including the research design and required research tools. Thus, the researcher went through theoretical and empirical both of the types of researches in this study.

The study has mainly been guided by the philosophy of constructivism in order to study and analyze teachers' perceptions subjected to contributing factor confined in students' role for their errors. Before the use of constructivism as a learning theory, errors were not positively viewed, just they used to be considered as a result of student's confusions and unfortunate products which had to be avoided and removed (Gagatsis & Kyriakides, 2000). If there are any gaps in understanding the mathematical concepts perfectly, the learning mathematics can be at risk by producing errors (Li, 2006). The errors are caused by applying prior inadequate knowledge in new situations (Gagatsis & Kyriakides, 2000). Some of the errors are germinated while using prior misconceptions to interpret mathematical concepts and problems in the classroom (Chauraya & Mashingaidze, 2017). These constructivist views towards errors focus on the main ideas and structure of misconceptions. They also give way outs on how these misconceptions are to be tackled and refined the ideas to be used in promoting further mathematical concepts.

Whilst facing new situations students recall their past knowledge and skills to interpret the new situations. According to Brodie (2014, as cited in Chauraya and Mashingaidze, 2017), when students attempt to use previously learnt knowledge in new situations, their past knowledge becomes incomplete for explaining new concepts and solving novice problems as a result errors occur. Thus, errors are seen as reasonable and sensible for students that they think what they are doing is correct. This reality of errors will enable teachers to deal with students' errors in appropriate ways. But for this, teachers need to have a positive perception towards students' errors.

According to Gagatsis and Kyriakides (2000), teachers' perceptions regarding students' errors can be classified into three classes like; investigating teachers' interpretations of common students' errors, explaining the reasons for students' errors and insighting of students' errors. This study targeted to investigate teachers' perceptions in the periphery of these phenomena specifically in the roles of students in making errors.

The ingredients extracted from these few literatures including others have been encoded and cited in different places as the guiding insights to understand teachers' perceptions in regard to students' varieties of mathematical errors. Further, in order to confine the area of study on specific issues and locate them in a new situation, it is essential to study empirical literatures. Few of them have been cited below.

Gagatsis and Kyriakides (2000) carried out a research about in-service teaches' understanding about the causes of students' errors and their opinions for particular errors. Then, they opined up that the teachers did not stick on students' attitudes only for making errors. They found and explained that mathematical content and the rules are also the causes of errors. Their study helped to investigate the teachers' understanding about the nature and sources of errors. This study has used their questionnaire with required modifications.

Chauraya and Mashingaidze (2017) studied about in-service teachers' perceptions and interpretations of students' errors in mathematics. They used a survey research design which incorporated questionnaire having two parts. In first part, they found out teachers' perceptions towards nature of errors whereas in second part, teachers were asked to describe five common algebraic errors. It helped to design a research method. It also supported to view errors as integral part of learning mathematics and examine how mathematics teachers view and explain students' errors.

Upadhyay (2001) has carried out a research on the effectiveness of constructivism in students' mathematics achievements. His study gave the philosophical, psychological and anthropological bases of constructivism which supported to capture teachers' perceptions towards students' construction and misconstruction of mathematical knowledge and skills. This study further helped to understand the T/L situation of Nepalese mathematics classrooms. There were other literatures which were also studied well and extracted their ingredients and used in this study but they have not been stated here because of limited space for the article.

VI. RESEARCH METHODOLOGY

A. Research Design

As per the nature of the study, the research design followed was mainly a qualitative though there were some quantitative data collected through survey questionnaire. The quantitative data were processed and dealt through the simple calculation and diagrammatical presentation. The researcher collected and used all the first hand data. The sources of data were all the responses of mathematics teachers. The qualitative data were collected through interviews and focus group discussions. In addition, the study conducted a survey research among the mathematics teachers teaching in different public schools.

B. Research Tools

The interview guideline, FGD guideline and survey questionnaire were prepared as the research tools for this study. The statements of the questionnaire for surveying purpose were prepared by following the Likert scale design. There were mainly seven themes of study to explore mathematics teachers' perceptions in regard to different learning roles and strategies of the students which are accountable to commit errors while learning mathematical concepts and solving the problems. However, the research tools were piloted in other two schools. Afterward, some simple changes were made in interview guideline. They were also consulted with senior researchers, colleagues and teachers before finalizing them.

C. Data Collection Procedure

By using interview guideline consisting seven themes of investigation, ten mathematics teachers of four public schools were interviewed one-by-one. Other nine mathematics teachers of two schools (each has four and five teachers) were engaged in FGD, separately, within the framework of FGD guideline. However, the interviews and FGD were conducted more like a normal conversation, but with a purpose to gain insights into teachers' views,

constructions, interpretations, and reasoning processes towards students' errors. The opinions of the teachers were recorded and later on transcribed as the theme of the investigation.

In order to take teachers' opinions in broader field one hundred sixteen sets of questionnaires were administered among the teachers of forty public schools. The schools were selected randomly from the list of the schools of Kathmandu Valley which consists of three districts. Out of which one hundred three were duly filled up and received back. In order to make a task of converting teachers' responses into percentage easier, those three sets were removed randomly and made a total respondents' number one hundred.

At the end, the analyzed results obtained from the qualitative information were verified with the help of the surveyed questionnaire. Further the information was triangulated with the findings of the previous studies and related theories. In this way, trustworthiness of the findings of the study has been established with the help of interviews, FGD, surveyed questionnaire, pre-existed findings and theoretical closure.

VII. ANALYSIS AND INTERPRETATION

First, the data obtained from interview, FGD and survey were organized in seven thematic areas for their systematic analysis process. As per the themes of the data, they were critically judged. The collected opinions and mostly teachers' experiences based narratives regarding those thematic areas have been analyzed and interpreted with reference to some previous researches and theories, mainly the theories of constructivism. The analyzed information were minutely scrutinized and cross checked in order to authenticate, strengthen and generalize the findings of this study. However, the qualitative information of seven themes of the study have been analyzed and interpreted, turn by turn, as follows.

A. Discussion and Analytical Presentation of Qualitative Information

1. Students' Learning Preparations

In a focus group discussion, a group of the teachers discussed about the issue of students' preparation for learning mathematics where they said:

> *Most of the students are sluggish and they read their mathematics copies in which they have copied the problems solved by teachers. They don't practice mathematics confidently and independently. Anyway, if they start to do mathematics and once they fail to get a correct answer of the problem they leave give up it.*

Other teachers argued that students' preparation has been hindered because of language problem as well, so they expressed their experience as follows:

> *In some of the cases, they also don't understand mathematical language as it is different than their community language. It is more happened in algebra while forming equations. They gave an example like students always feel difficulty in changing given problem into algebraic equation where they make mistakes while balancing the equations as well.*

Regarding mathematical language, another teacher added like:

> *Students think that a smaller amount of rupees is needed in case of money is devaluated. But in contrary, the answer of the given problem comes with larger amount of money. For example, if Nepalese rupee is devaluated it needs more amount of money to exchange with dollars.*

These narratives mean there are two kinds of preparation such as mental and physical. In order to be mentally prepared the students should be confident enough to start with solving mathematical problems. Regarding physical preparation, they should be ready to learn with book, copy, pen, geometry box and other materials if needed along with their right body posture. Some of the lazy students just hold copy which has solved problems by teacher which they read by sitting in bed or even by sleeping. In this way, the conflict emerged when a student's intuitive

representation is not adequate as Fischbein (1994, cited in Egodawatte, 2011) claimed. Further, their preparation and promptness has been derailed in the lack of students' friendly mathematical language. Actually, there are numerous mathematical words, phrases, terminologies, definitions, symbols etc. which are different than house-hold language. They cause dilemma in students so that they commit errors (ibid).

2. Students' Attitude Towards Learning Mathematics

According to the teachers, students think that mathematics is a tough subject so that it is not for all. It means, it can be learnt by only those students who are position holders like first, second and so on in the class. They said, "Students have math-phobia". They added that students have anxiety, nervousness, misinterpretation and slips. As a result, they commit many errors as claimed by Radatz (1979, cited in Campbell, 2009).
One of the teachers reported a bit differently. He said, "Mathematics is taken as a hard subject because of mathematics teacher's superiority as they want to show among students". He further added:

> *Teachers should have oriented students in such a way that they could feel it an easy subject which can be learnt by those lazy and weak students. Even they can learn it while playing and solve the problems while watching television. Students should enjoy not only on solving problems rather making some hypothetical questions and solving them.*

But, students have no positive attitude towards mathematics even they have no patience to understand and give out some tries to solve it, as the teachers reported. When students get mistakes, they don't review the process. Instead, they give up it and feel that they are not for mathematics. The phenomenon of neural network theory as explained by Matlin (2005) was found applicable in this student's action where the students could not apply the correct method in the first attempt while solving the problems then they give up them.

3. Students' Psychological Situation While Learning Mathematics

One of the senior teachers opined up that the students may perceive mathematics as a fun and make a positive attitude towards it if teachers create math-learning joyful and students' friendly-environment in the classroom. He added:

> *The teachers teach the front benchers and spread terror to rest of all. They said that good learners are praised every time but, in against, they sought to the weaker ones. The weak students are not assured as if they learnt and knew mathematics. They even don't dare to ask questions with teachers.*

In this situation, how students can learn and make progress in mathematics. With this psychology they face more errors as and when they go for its homework. Thus, they take copies of good learners and copy it, as a teacher reported. If so, they could not clear their misconceptions and again make errors. Another teacher said, "When I go to classroom in mathematics period, students feel that they are dizzying as if they are sitting in a moving bus". Thus, it needs to make mathematics practical so that the students take mathematics as a game and play with it, raise confidence, learn it and develop a positive attitude (Bishop, 2008) as they do a bit in measurement unit and some part of geometry.

4. Students' Capabilities to Learn Mathematics

The teachers reported, "Those students who imagine more with less concentration make numerous errors". They added that those kinds of students do have inner calculations and even jump up some steps as well. Some of the students use calculator in sequential order while solving mathematical problem which doesn't work correctly.

Other teachers claimed that students have incomplete pre-requisite knowledge and skills. Actually, they might have mastered the fundamental concepts in their previous classes. They need more time, patience, and practice but they give more time for playing gadgets and watching television programs. It means these activities of the students have limited their capacity in learning mathematics. As claimed by Matz (1980), because of limited capabilities, some of the errors are even revealed by using the known formulae in new situation inappropriately,

5. *Students' Wrong Perceptions*

Teachers' experience reflected that students have learnt mathematics through rules and formulae. They have made them more technical even they memorized the learning steps. At least, they should have known about how the rules and formulae developed from the real ground. If they are learnt by memorizing instead of having conceptual learning, they do not work longer. One of the teachers said:

> *While teaching in small classes, we could not make some mathematical concepts clear as they did not have a required level of vocabulary and understanding so we guide their learning through some rules. For example, teaching HCF and LCM, operations in fractions, measurements, algebraic expressions etc. Then they go to upper classes without having their particular and meaningful learning. On that class, teachers assume that they have learnt those things in earlier classes.*

As a result, the students remain with imperfect knowledge so, they make errors. Moreover, students have many wrong concepts and generalizations like, multiplication gives always greater numbers, fractions are always smaller quantities, 'of' means only multiplication etc. In this regard, Demby (1997, cited in Campbell, 2009) argued that students tend to go through a phase of wrong perception before achieving fluency in manipulative skill. Some of the errors are also due to wrong visualization and coherence of the rules as in the case of developing formula for $(x + y)^3$ from $(x + y)^2$.

Teachers added that it is easy to teach students with no knowledge rather than with wrong knowledge. As a reason, they said that it needs to apply additional efforts to erase those misconceptions before making them ready for learning.

6. *Situation of Violating Mathematical Rules*

A group of teachers said that students don't violet the mathematical rules, steps and formulae knowingly but it happens unknowingly. Matlin (2005) argued that errors are logically consistent and rule-based rather than occurring randomly. The students follow the wrong process as thinking that they are correct but reach nowhere. They added that violation of rules come to be happened because of following rote learning process, being over confident, jumping the steps, being impatience, lack of concentration, anxiety, restless, nervousness, hurried etc. One of the teachers said:

> *I see in my class, when students are asked to find square of 16 they write its answer 4 because their mind is clicked immediately on square root of 16 as they are used to for this. Similarly, they know* $Sin^2A + Cos^2A = 1$ *then they write 1 for their any power like;* $Sin^3A + Cos^3A$ *or* $Sin^4A + Cos^4A$ *and so on.*

It means students have a pre-fixed mind mapping which causes errors as claimed by (Bishop, 2008).

7. *Interpretation and Generalization of Mathematical Concepts*

A teacher started to share her experience with an example like:

> *'Father is twice as old as his son' where we suppose father's age is x years and his son's age is y years. In this case, students write it algebraically as 2x = y just by reading thoroughly from left to right which is wrong as it has not got to be a balanced equation.*

Another teacher said, "Students think that plate, ball, and bangle are all examples of circle which is a wrong generalization. It seems that they have not verified the definition of circle that under which phenomenon it is drawn. However, it causes the errors due to wrong interpretation and generalization because of dissimilar code of language with misconceptions as claimed by Egodawatte (2011).

B. Analytical Presentation of Surveyed Data

Actually, the survey research was carried out to take the research into a broader domain of investigation which helped to strengthen and authenticate the qualitative information. For, as mentioned above, the statements in

the questionnaire were related with seven themes regarding students' roles that contribute to generate mathematical errors. In order to take the responses of the teachers, there were five levels of choices. They were as 'agree (A)' and 'strongly agree (SA)' for representing their agreement in the statements whereas 'disagree (DA)' and 'strongly disagree (SDA)' for representing disagreement upon the given statements. Further, there was a provision of 'undecided (UD)' if they are not that much sure about their opinions. But, finally these five options were categorized into three choices as per their responses which were more squeezed in agreed and very few in disagreed and undecided. There were one hundred three questionnaires which were duly filled up and received back in hands. The three questionnaires were randomly removed in order to express easily the frequencies of each statement into percentage.

There were altogether seven statements. The percentage of collective responses of the teachers in each statement has been depicted in the following diagram. At the end, the diagrammatical presentation has been followed by their analysis and interpretation.

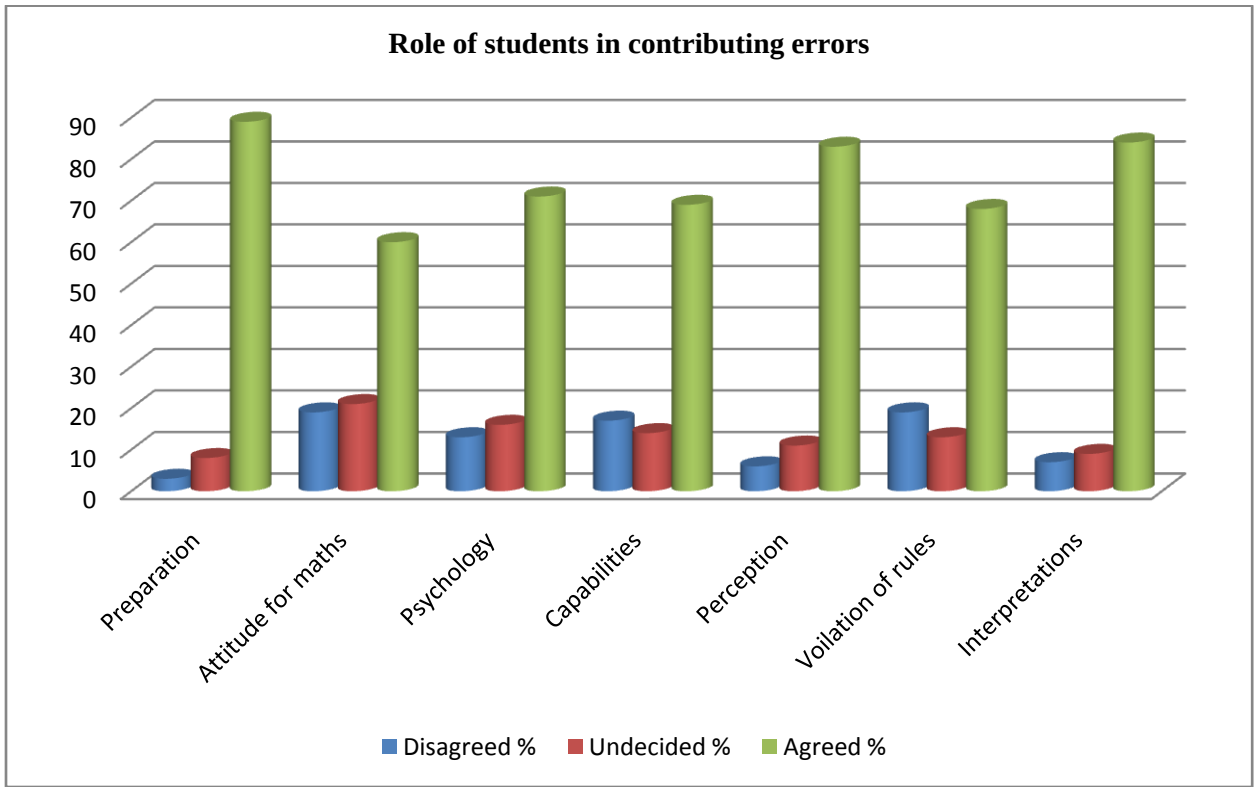

Diagram 4.1: *Role of students in contributing errors*

The diagram shows that most of the teachers have clearly marked on a big role of students to produce errors. Among the seven possible factors related to generate errors, the three have scored more than 80%. They are as lack of students' readiness to learn mathematics, wrong perceptions and incomplete knowledge, and inaccurate interpretation and generalization of mathematical concepts. However, no item has scored less than sixty percent in it. These findings have been found to be more or less consistent with the research study carried out by Gagatsis and Kyriakides (2000).

VIII. FINDINGS OF THE STUDY

There are numerous factors which cultivate and harvest students' errors. However, this study was mainly confined in the roles played by the students for committing mathematical errors. In this regard, the majority of the teachers indicated that errors were due to student-related factors such as lack of adequate preparation and reading mathematics, no good attitude towards mathematics, students' psychological situation, limited capabilities, wrong perception or incomplete knowledge since earlier grades, violation of rules, and incorrect interpretation along with improper generalization of mathematical content. Further, mathematics is a rule dominant subject. In this situation, the errors could be the results of confusing concepts and lack of break through the overlapping rules. Teachers

realized that they taught to memorize rules or steps of solving problems without having clear concepts of their meanings. Such a process leads students to forget or mix up the processes and commit errors.

The teachers also agreed that errors could be useful sources of inquiring mathematics logically and consistently. It indicated that errors are part and parcel of mathematical content and learning process. In this way, erring is not a matter of blaming students. However, there were few teachers who thought that they knew where students make errors, and errors are avoidable too. Further, they were a bit likely to point out finger towards students for their errors. These kinds of teachers showed the correct solution of problems to the students without engaging them in errors. Actually, it was an erroneous thinking behind the errors.

IX. CONCLUSION

The errors are rampant in students' mathematical tasks at any level of the school. The overlook of errors has got continuity since a long time as still there is no error analysis system and treatment plan. Actually, neither such a system and plan is taught in any level of course in college nor it has been a content of teacher training program. In this context, this research has unveiled the perceptions of teachers towards the different roles of students' for making mathematical errors. Actually, there is a gap between committing errors by the students and understanding their errors by the teachers. Until and unless, the teachers get break through the gap, they cannot be engaged productively to address students' errors. Thus, teachers should learn about origin, nature, causes and adverse impact of errors in the college level courses or pre-service or in-service trainings. If so, it will help teachers to be more professional instead of blaming students for their errors.

In this regard, teachers' belief in mathematics as absolute knowledge needs to be changed into mathematical knowledge as fallible and human activity so that teachers could give importance to every reason or argument of the students. So, they tend to analyze students' each and every reasoning even no matter whether it is right or wrong. The error analyzing and treating strategies are therefore essential not only to minimize or wipe out the errors, but also to prevent them. The teachers should not be anxious of students' errors. Even the students' wrong answers can guide to reach to the origin of errors that they may be the best tools for crafting their learning experiences. Thus, teachers should develop 'error analysis and treatment plan' and implement among the students to make their learning mathematics errorless, joyful and meaningful.

X. IMPLICATIONS OF THE STUDY

As per the opinions of the teachers, the students who learned by committing errors were able to achieve stronger conceptual foundation in the comparison of those who did not commit errors in the first attempt. Thus, the errors should not be a hindrance to learning mathematics. Moreover, the errors serve as a purpose of constructive and adaptive tools for promoting and crafting conceptual understanding. Thus, in the process of correcting or searching for the origins of errors, students reach a better understanding of their own mathematical reasoning. In this context, this study has drawn many prominent implications which can be used by students and teachers in daily T/L practices of mathematics. Further, its implications have been identified for subject experts. At expert level, it is expected to be equally applicable to policy makers, curriculum developers, training package creators, teacher educators, book writers, trainers and teachers. This document can also be a part of training material for pre-service and in-service teachers as well.

ACKNOWLEDGEMENT

This research study was carried out under the guidance and support of Research Management Cell (RMC), MR College, Kathmandu. So, my sincere thanks to those highly scholar researchers of RMC for their guidance, constructive comments, suggestions and inputs which were provided me throughout this study. I would also like to thank my colleagues of mathematics departments who facilitated my research work by various means. At last but not the least, I am thankful with all sampled schools and their teachers for providing me their commendable help as and when needed.

REFERENCES

[1] Bishop, A. and et al. (2008). Educational algebra: A theoretical and empirical approach. Boston: Springer
[2] Campbell, A. (2009). Remediation of first-year mathematics students' algebra difficulties. M. Sc. Level Dissertation. University of Kwazulu-Natal.

[3] Chauraya, M. & Mashingaidze, S. (2017). In-service teachers' perceptions and interpretations of students' errors in mathematics. International Journal for Mathematics Teaching and Learning 2017, Vol. 18.3, 273 – 292.
[4] Egodawatte, G. (2011). Secondary school students' misconceptions in algebra. An unpublished dissertation. Canada. University of Toronto. Retrieved on April 17, 2018 from http://hdl.handle.net/1807/29712
[5] Gagatsis, A., & Kyriakides, L. (2000). Teachers' Attitudes Towards their pupils' Mathematical Errors. Educational Research and Evaluation, 6(1), 24-58.
[6] Hill, H., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. American Education Research Journal, 42, 371-406.
[7] Kshetree, M. P. (2013). Extracting Errors in Mathematics Learning. In (Ed.) Mathematics Education Forum. II (34) (pp 15-18). Kathmandu: Council for Maths Education.
[8] Li, X. (2006). Cognitive analysis of students' errors and misconceptions in variables, equations, and functions. Doctoral dissertation. Texas A and M University. Retrieved on January 2, 2015 from http://oaktrust.library.tamu.edu/bitstream.
[9] Matlin, M. W. (2005). Cognition. USA: John Wiley and Sons.
[10] Matz, M. W. (1980). Towards a computational theory of algebraic competence. Journal of mathematics behavior, 3(1), 93-106
[11] Upadhyay, H. P. (2001). Effect of constructivism on mathematics achievement of grade V students in Nepal. Doctoral dissertation. Chandigarh: Punjab University.