International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 05, May 2026)

A Study of Mathematical Diagnostic and Prognostic Competencies among Prospective Teachers studying under different Teacher Education Programs

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***Abstract*-- This research presents an analysis of the diagnostic and prognostic competencies of prospective teachers within various teacher education programs. The research seeks to understand the extent of these competencies, the scope of differentiation of paradigms in teacher education, and the impact of these competencies. A descriptive survey method was used. The population was comprised of prospective teachers studying at teacher education institutions in Darbhanga, Bihar. A sample of 140 prospective teachers (B.Ed. & D.El.Ed. students) was selected using the purposive sampling technique. Data were collected through a self-developed Mathematical Diagnostic and Prognostic Competency Questionnaire (MDPCQ), which comprised items based on a five-point Likert scale. The collected data were analyzed using mean, standard deviation, t-test, and Pearson's coefficient of correlation. The findings showed that the level of both mathematical diagnostic and prognostic competencies of prospective teachers was moderate. It was further found that there was no major difference between B.Ed. and D.El.Ed. prospective teachers with regard to their diagnostic and prognostic competencies. A significant positive correlation was observed between diagnostic and prognostic competencies of prospective teachers. This study highlights that prospective teachers have the basic competencies to identify the learning challenges of students and to forecast their performance; however, there is a considerable scope of enhancement, which could be done by incorporating more training and practice. The findings emphasize the need to enhance the teacher education programs to improve the quality of mathematics teaching within the teacher education curricula.**

***Keywords*-- Mathematical Diagnostic Competency, Mathematical Prognostic Competency, Prospective Teachers, Teacher Education Programs, Mathematics Education**

I. INTRODUCTION

Education in mathematics is beneficial in helping students be more logical, more analytical, and an overall better problem solver. While teaching students mathematics is important, it is equally (if not more) important that a teacher identifies their students' needs in order to be a better mathematics teacher. This is where diagnostic and prognostic competencies are discussed in teacher education. Diagnostic competence is necessary for a mathematics teacher in order to find a student's learning gap, identify their learning needs, and ultimately improve the student's performance in mathematics.

Many studies have shown that an effective teacher is one who continually diagnoses their students, and as a result of this, has a positive effect on the overall quality of the learning (Artelt, 2009; Schrader & Helmke, 1987). This is further elaborated on when it is stated that the better a teacher can continually diagnose their students' needs, the more effective their learning will be (UNESCO, 2006). It has also been shown that diagnostic competence is influential when discussing teaching effectiveness and learning outcomes (Rajak et al., 2025). Diagnostic competence has also been shown to be a combination of different aspects such as knowledge, skills, and different thought processes. For example, Spinath (2005) believed that teachers' capacity to assess students cannot be performed as a single activity. In the same way, Binder & Krauss (2018) believed that diagnostic skills are one of the best predictors of students' mathematical success, and in turn, are of great value to education. It is vital for teacher education programs to provide opportunities for aspiring teachers to learn how to analyze their students' cognitive processes, identify thinking errors, and understand how to tailor their instructional strategies. It has been found that designing a training program that offers a combination of practical experience and pedagogical content knowledge can improve students' diagnostic judgments (Ostermann & Leuders, 2018; Heinrichs & Kaiser, 2018). Furthermore, Rahman et al. (2025a) state that there is an undeniable need for creative and innovative transformations in teacher education programs. Diagnostic competence is important, but forecast competence is equally critical, as it is with forecast competence that learning goals and strategies are determined. This includes anticipating students' future learning and instructional needs. It has been pointed out by researchers like Tonova (2021), that teacher competencies are characterized by an array of integrated knowledge and skills essential for high-level performance in the field of education. There are countless opportunities for expanding and innovating the teaching and learning processes with the integration of Artificial Intelligence. It can serve as an ally for personalized learning and informed instructional decisions (Rahman et al., 2026). NEP 2020, along with ITEP, aim to promote the integration of both pedagogical and content knowledge in order to nurture the professional teacher identity (Rahman et al., 2026a).

Several researchers have explored a variety of methods to improve diagnostic competence among future teachers, and one such method has been highlighted in the work of Schons (2023). Schons, explained the importance of teachers having diagnostic skills to identify student learning gaps and cognitive errors, and explained the benefits of incorporating simulation-based training programs for teacher education. Likewise, Wildgans & Scheuerer (2020) created virtual settings to analyze and advance diagnostic strategies. Their work proved beneficial to teacher training. In addition, research shows that diagnostic task design and response analysis remain critically important and under-researched components of teachers' work. Lim (2021) noted that instructional assistance for diagnostic thinking and assessment construction was lacking in teacher training. The need to develop strong diagnostic skills rose because of classroom diversity and the need to evaluate the characteristics and learning potential of different groups of students (Ohle & McElvany, 2015). Mathematics incomprehension can cause significant problems with regard to learning. Previous studies indicate diagnostic teaching is beneficial for improving students' performance by addressing errors and misunderstandings (Busch & Leuders, 2015). Furthermore, appropriate diagnostics aids in effective classroom management and instructional planning, which have positive impacts on teaching and learning process (Galustyan, 2018). Although there is an increasing emphasis on diagnostic and prognostic competencies, a number of studies indicate that, in general, adequate preparation in these competencies is lacking in prospective teachers. This is due, among other things, to a lack of pedagogical content knowledge, practical experience, and adequate teacher training (Zaidi & Ali, 2019). Training research within and outside of teaching reinforces the significance of the availability of continuous, context-related training for the enhancement of teaching competencies (Rahman et al., 2025b). Therefore, it is appropriate to evaluate the impact of teacher training on the enhancement of these competencies in prospective teachers. Accordingly, this study is devoted to exploring the outcomes of teacher training on enhancement of prognosis and diagnosis competencies in Mathematics among prospective teachers. This is to ensure proper prognosis of teacher training in Mathematics, and consequently, to ensure possible optimization of the teaching and learning of Mathematics.

II. Review Of Related Literature

From a historical perspective, the diagnostic competence of teachers is one of the hallmarks of a professional teacher. An early example is Schrader & Helmke (1987), who argued that the ability of teachers to judge the prerequisites of learners is critical for effective instructional design.

Artelt (2009) argued that diagnostic competence is key to the enhancement of the quality of schools. Relatedly, diagnostic teaching, defined by UNESCO (2006), is a form of teaching within which teachers are able to comprehend the level of learners' understanding before, during, and after teaching. This form of teaching is an enhancement of the effectiveness of the teaching process. Some researchers have also studied the various dimensions of diagnostic competence. Spinath (2005) stated that diagnostic competence is not a single unified construct but rather is the outcome of the interplay of a number of cognitive strategies. In this vein, Binder & Krauss (2018) situated diagnostic competences as one of the key determinants of learners' performance in mathematics. Philipp (2018) further stated that the diagnostic competence of teachers is one of the contributory factors to the success of the learning of students. In prospective teachers, the development of diagnostic competence has been the focus of some research studies. Heinrichs & Kaiser (2018) stated that university courses change the way future teachers diagnose students' errors and how they respond to those errors. In the same vein, within the context of a short course, Ostermann & Leuders (2018) posited that the pedagogical content knowledge of prospective teachers is amenable to improvement in their diagnostic judgment. Reinhold (2018), too, underscored the necessity of courses that are structured to help teachers diagnose the educational strategies of prospective teachers. Diagnosing student thoughts and learning in mathematics education is crucial. Busch and Leuders (2015) argued that effective mathematics lessons require the use of formative diagnostic assessments. Prediger and Zindel (2017) also analyzed the prospective teachers' interpretations of the mathematical thinking of students, and the importance of diagnostic interpretation of students' thinking. More recent research explored different methods of developing diagnostic competence. Wildgans and Scheuerer (2020) constructed computer-simulated environments, Balanced Diagnostic Systems, which both evaluate and support diagnostic thinking, and proved to be very successful. Schons (2023) researched the diagnostic thinking of teachers in relation to uncovering students' misconceptions. Schons also commented on the effects of the use of simulation-based education, although the results of the research showed the use of scientific scaffolding had almost no effect on the participants' points of view. The importance of teacher education in developing the above mentioned competencies is also recognized in the literature. Tonova (2021) described teacher competencies as combining relevant knowledge and expertise to make an impulse to outstanding performance. Lim (2021) argued that developing diagnostic inference competencies and constructing diverse assessments were critical to the foundation of an education system, integrated with effective teacher education.

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Zaidi and Ali (2019) argued that the integration of mathematics pedagogy and teacher education to overcome teaching barriers and address learner misconceptions, especially in the mathematics learning process, is of utmost importance. Challenges in developing diagnostic thinking were also noted in this literature. Ohle and McElvany (2015) noted that the increasing diversity of students in classrooms makes diagnostic thinking even more important. Yaghmour (2016) also noted that teachers generally possess basic diagnostic competency, and there were valid reasons to believe that teacher education should address this area more to produce more competent teachers. In general, the literature suggests that diagnostic and prognostic competencies are crucial in teaching mathematics. Although many research studies reported on the diagnostics of teaching competencies, the impact of teacher education on developing the diagnostic and prognostic competencies of future educators of mathematics is still unexplored. Thus, the proposed research will help fill this gap.

Need and Significance of the Study

Currently, teaching mathematics effectively is more than describing how to solve a problem. Teachers must be able to support students in overcoming challenges and understand how to scaffold and extend students' progress. Teachers who are competent in diagnostics and prognostics are able to determine errors and plan instructional techniques that are more efficient and focused on the learner. It is clear that many future educators have not developed these competencies. As a result, there is a definite gap in the offered teacher education where the capacity to diagnose errors and predict learning is not developed. Teacher education has the potential to close this gap, and if these competencies are developed, the prospects of future educators are enhanced. In this regard, the present study is relevant in that it attempts to describe the impact of teacher education on developing diagnostic and prognostic competencies in mathematics of future teachers in order to improve the standards of mathematics education.

Objectives of the Study:

1. To study the level of mathematical diagnostic competencies among prospective teachers.
2. To assess the level of mathematical prognostic competencies among prospective teachers.
3. To examine the differences in mathematical diagnostic and prognostic competencies of prospective teachers studying under different teacher education programs.
4. To find out the relationship between mathematical diagnostic and prognostic competencies among prospective teachers.

Hypotheses of the Study:

1. There is no significant difference in the mathematical diagnostic competencies of prospective teachers studying under different teacher education programs.
2. There is no significant difference in the mathematical prognostic competencies of prospective teachers studying under different teacher education programs.
3. There is no significant relationship between mathematical diagnostic and prognostic competencies among prospective teachers.

III. Methodology

Descriptive survey method has been used in this study to assess mathematical diagnostic and prognostic competencies of future teachers. The study population includes future teachers who are studying in teacher education institutions in Darbhanga. A sample of 140 future teachers (B.Ed. and D.El.Ed. students) has been recruited from various teacher education institutions of Darbhanga. The sample has been selected using purposive sampling method to ensure that the study participants are the most relevant to the study goals. To collect the study data, a self-made Mathematical Diagnostic and Prognostic Competency Questionnaire (MDPCQ) has been used which comprises of the items of diagnostic and prognostic competencies which are examined using five-point Likert scale. The questionnaire also has a section of background information based on which relevant information of the respondents is collected. The data have been collected by administering the questionnaire to the selected sample under normal conditions. For the analysis of data, mean and standard deviation has been calculated to assess the mathematical diagnostic and prognostic competencies of future teachers. To assess the significant differences of competencies, pertaining to teacher education programs, the t-test has been applied and to assess the diagnostic and prognostic competencies, Pearson's coefficient of correlation has been used.

IV. Analysis And Interpretation Of Data

This study analyzes and interprets data to form the foundation for logical conclusions. The data from the developed questionnaire were systematically arranged, classified, and analyzed using the measurement and statistical analysis techniques that were deemed appropriate for the research. Mean and standard deviation were used to analyze the level of mathematical diagnostic and prognostic competencies among the teacher trainees, and the t-test was used to compare the teacher training programs. To analyze the relationship between diagnostic and prognostic competencies, Pearson's correlation coefficient was used. The outcomes of the analysis were interpreted based on the aim and hypotheses of the research.

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Objective 1: To study the level of mathematical diagnostic competencies among prospective teachers.

Table:
Mean and Standard Deviation of Diagnostic Competency (N = 140)

S.No	Items	Mean	SD
1	Q1	3.02	0.69
2	Q2	3.16	0.66
3	Q3	3.06	0.66
4	Q4	3.11	0.77
5	Q5	3.06	0.65
6	Q6	2.99	0.68
7	Q7	3.19	0.70
8	Q8	3.07	0.76
9	Q9	3.03	0.70
10	Q10	3.14	0.69
—	Overall	3.08	0.38

Interpretation

The mean scores for the items on mathematical diagnostic competencies, as shown in the table, fell in the range of 2.99 to 3.19. This indicates that responses were centered at the middle of the Likert scale. Therefore, it can be reasonably inferred that the respondents displayed some degree of agreement. The highest mean score was reported for Q7 (3.19), which means that prospective teachers tend to show better performance in the assessment of students' thinking as compared to Q6, which received the lowest mean score (2.99). This suggests that respondents have less confidence in the identification of students' learning challenges. The mean (2.99 for Q6, 3.19 for Q7) shows a relatively lesser degree of range of responses. The standard deviation of the items was reported to be in the range of 0.65 to 0.77. This indicated that even though the responses were consistent to a certain degree, there was some degree of variability regarding diagnostic competencies among prospective teachers.

The overall mean score was 3.08, this indicated that mathematical diagnostic competency of respondents was at a moderate level. This suggests that the respondents have basic skills related to the identification of errors, misconceptions, and gaps in students' mathematical knowledge, and related skills are not advanced to a higher level. The overall standard deviation of the responses being at 0.38 suggests that the responses being fairly evenly distributed reflects the competencies being relatively consistent amongst most respondents.

It can be inferred, in general, that prospective teachers are developing competencies related to diagnostic skills based on the data collected. However, there is a need for enhancements aligned with specific frameworks and standards that take a solid focus on practice-based pedagogy to enable teachers to diagnose students' learning challenges in mathematics effectively.

Objective 2: To assess the level of mathematical prognostic competencies among prospective teachers.

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Table:
Mean and Standard Deviation of Prognostic Competency (N = 140)

S.No	Items	Mean	SD
1	Q11	3.13	0.68
2	Q12	3.10	0.66
3	Q13	3.04	0.75
4	Q14	2.99	0.65
5	Q15	3.06	0.73
6	Q16	3.01	0.66
7	Q17	3.14	0.74
8	Q18	2.99	0.71
9	Q19	3.08	0.73
10	Q20	3.09	0.71
—	Overall	3.06	0.40

Interpretation

The table shows that items concerning mathematical prognostic competencies have means ranging from 2.99 to 3.14. This denotes that responses of prospective teachers are concentrated on the midpoint of the Likert scale, meaning that respondents tend to slightly agree to a limited extent with the measurement of prognostic competencies. The highest mean score of the items is found in Q17 with a score of 3.14. Meaning the respondents are good at 'modifying' teaching methods to 'adapt' to the performance of students. Q14 and Q18 have the lowest mean scores of 2.99, meaning that respondents are least confident about 'anticipating' the 'learning' challenges that students face and predicting students' responses to 'novel' Vs teaching 'concepts' that are new to them. The standard deviation of each of the items falls within the range of 0.65 to 0.75, meaning that the distribution curve of responses was moderately normal. This means that there was a reasonable degree of agreement among the responses of the prospective teachers on how they perceive their prognostic ability. The mean score of the items was 3.06 that illustrates that the sum of mathematic prognostic competencies of the prospective teachers is moderate. This means that respondents are 'comparatively' able to 'predict' the potential performance of students, 'design' teaching strategies, and 'foresee' some learning challenges, but are 'relatively' unable to handle these competencies with 'expert' skills. The overall standard deviation of 0.40 indicated that responses from the survey were consistent, which suggested that most respondents had a similar level of competency.

The research indicates that prospective teachers have a rudimentary level of prognostic competency that needs improvement, and that needs to be addressed through better training, practice, and experiential learning in case of the teacher education courses. This will assist the teacher trainees to better anticipate and facilitate learning in the area of mathematics for their students.

Objective 3: To examine the differences in mathematical diagnostic and prognostic competencies of prospective teachers studying under different teacher education programs.

H_{01}: There is no significant difference in the mathematical diagnostic competencies of prospective teachers studying under different teacher education programs.

H_{02}: There is no significant difference in the mathematical prognostic competencies of prospective teachers studying under different teacher education programs.

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Table:
Comparison of Diagnostic and Prognostic Competencies between B.Ed and D.El.Ed Students (N = 140)

Variable	Group	N	Mean	t-value	p-value	Result
Diagnostic Competency	B.Ed	70	3.06	-0.66	0.51	Accepted
	D.El.Ed	70	3.11			
Prognostic Competency	B.Ed	70	3.04	-0.65	0.52	Accepted
	D.El.Ed	70	3.09			

Interpretation

This table offers an analysis of the mathematical diagnostic and prognostic competencies of the B.Ed and D.El.Ed prospective teachers. From the means, it can be seen that the D.El.Ed participants have higher means of diagnostic competency (3.11) and prognostic competency (3.09) compared to the B.Ed participants, who have means of 3.06 and 3.04, respectively. However, the differences in means tend to be minimal and competency levels tend to be similar for both groups. The independent sample t-test results show that for diagnostic competency, the t-value was -0.66, the p-value was 0.51, and for prognostic competency, the t-value was -0.65, and the p-value was 0.52. Since both p-values are higher than 0.05, which is the level of significance, the difference between the two groups is said to be statistically insignificant. Therefore, it can be concluded that the mathematical diagnostic and prognostic competencies of D.El.Ed and B.Ed prospective teachers are similar. The results indicate that both groups are able to recognize learners' errors and learning gaps and predict learners' learning trajectories and formulate learning interventions. The type of teacher education program has no significant effect on the prospective teachers' competencies, and it can be assumed that both teacher education programs offer similar experiences and opportunities to gain competencies.

Based on the findings, the null hypotheses H_{01} and H_{02} are accepted as neither of the two groups of prospective teachers showed statistically significant differences.

Objective 4: To find out the relationship between mathematical diagnostic and prognostic competencies among prospective teachers.

H_{04}: There is no significant relationship between mathematical diagnostic and prognostic competencies among prospective teachers.

Table:
Correlation between Diagnostic and Prognostic Competencies (N = 140)

Variables	N	Correlation (r)	p-value	Result
Diagnostic & Prognostic Competency	140	0.78	0.000	Rejected

Interpretation

The table presents the relationship between the mathematical diagnostics and prognostic competencies of prospective teachers. The computed Pearson's r is 0.78, which indicates a considerable positive relationship between the two variables involved. The results indicate that prospective teachers who have more developed diagnostics competencies have more developed prognostic competencies as well. The resultant p-value is 0.000, which is less than the significance level of 0.05. Thus, the relationship of the two variables is statistically significant and cannot be considered a coincidence. Therefore, the null hypothesis is not accepted, and it is assumed that a significant relationship exists between the two mentioned competencies.

There is a close and positive relationship between the two mentioned competencies, and it is assumed that the development of one will enhance the development of the other. Teachers who are good at diagnostic skills will be good at prognostic ones too. Diagnostic skills help teachers identify misconceptions and the difficulties students experience. Therefore, the findings emphasize the importance of both diagnostic and prognostic skills in teacher training as integrating one may lead to the enhancement of the other.

Thus, it can be concluded that the mathematical diagnostic and prognostic competencies of prospective teachers are positively interrelated.

V. Discussion

The aim of this research was to discover diagnostic and prognostic competencies in mathematics of prospective teachers and examine the level, differences, and relations of each. The outcomes of the present study offer a description regarding the diagnostics and prognostics competencies for all prospective mathematics teachers enrolled in teacher training programs. The analysis focused on the first objective showed that their level of mathematical diagnostic competency was average. This means that the participants have a basic knowledge of how to detect the errors and misunderstandings and explain the learning problems and hurdles of students, but they have not reached the mastery of those skills. The finding illustrates that teacher training programs are likely to have some influence in the development of diagnostic skills, but there is still a need for other activities and degree of concentration. The findings of the second objective also showed that the level of mathematical prognostic competency was average. This means that the prospective teachers are likely to be able to anticipate the future learning outcomes of students and design learning activities for them, but still, the competencies are likely to be at a superficial level and need to be deepened and sustained. The results related to the third objective showed that there is no (or very negligible) difference in the diagnostic and prognostic skills of the prospective teachers who are being trained in B.Ed and D.El.Ed. programs. This means that both of the teacher trainings offer similar opportunities and environments to enhance these competencies. The relative lack of noticeable differences may suggest that the curriculum and training methodologies in the two programs are more or less balanced in their capability to design and develop diagnostic and prognostic skills. The results of the fourth objective suggested a strong correlation that was both positive and significant for diagnostic and prognostic skills. This shows that diagnostic and prognostic skills develop simultaneously. Teachers in training who can identify learning problems diagnosed in students can also anticipate learning outcomes and the associated interventions. This relationship shows the nature of integration of the skills and the necessity to develop both complementary skills together in teacher training programs. The results of the study also support previous studies which demonstrate that the art of diagnosis is very critical to effective teaching and is integrally related to the planning of instruction and the achievement of learners. The moderate degree of related skills that was found in the current study was also consistent with the results from previous studies that showed that teachers in training lack the requisite skills and hence need support to develop them.

VI. Conclusion

On the basis of interpretation of the data, we conclude that prospective teachers have a moderate level of mathematical diagnostic and prognostic competency. They have a basic skill level of identifying students' learning challenges and predicting their future performance, and these skill levels can be improved upon. In this study, it was also found that there is no considerable difference in the levels of diagnostic and prognostic competencies in either B.Ed or D.El.Ed prospective teachers. This shows that both of these teacher education programs are equally satisfactory in nurturing these skills. There is also a strong and significant correlation between the two, showing that both diagnostic and prognostic skills are interrelated and develop together. Improvement of one skill will lead to the improvement of the other. Considering the results, it is evident that teacher education programs should involve practical placements that incorporate diagnostic assessment and opportunities for reflective teaching practice. With the improvement of these competencies, effective mathematics teaching and positive learning outcomes for students will be achieved.

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