



Impact of Teacher Education Programs on Mathematical Prognosis and Diagnosis Competencies of Prospective Teachers: A Review of Literature

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ABSTRACT

Teaching education programs strive to encompass the creation of professional skills in aspiring educators for the enrichment of their educational systems. Evaluation and prediction competencies are particularly important for the refinement of the teaching and learning systems. Diagnostic competencies involve the educators' comprehension of the students' learning obstacles and errors, as well as their understanding and acceptance of the material. Prognosis competencies entail the understanding of students' future learning potential and the development of the required teaching strategies. Having these competencies, educators are able to make beneficial teaching choices and assist students in their learning journey. The study goal is to summarize the research done on prognostic and diagnostic competencies in teacher education. The purpose of this study is to determine the trends in the research, and for this, the author analysed 36 studies in this field. The studies are grouped according to the area of research to which they belong. These areas are prognostic and diagnostic competencies in teaching mathematics, diagnostic competencies of future educators, roles of teacher education, diagnostic and simulator-based tools, and research in diagnostic competencies. The studies indicate that diagnostic

competencies are associated with educators' pedagogical content knowledge and their ability to unpack students' thinking. Additional studies show that prospective teachers have difficulty in the accurate diagnosis of students' learning issues as well as the prediction of students' learning advancement. Thus, the teacher education programs are essential in the building of such skills, especially with the aid of the pedagogical instruction, the practical classroom teaching, and the teaching reflective activities. Besides, the recent studies have revealed the increasing importance of the pedagogical technology and the simulated teaching environment in enhancing the teachers' competencies of the diagnosis. In summary, the review studies, while acknowledging the progress in teacher education, emphasize the need to develop the diagnosis and prediction competencies of prospective teachers and in doing so, identify several areas that are understudied.

Introduction

Teaching competency programs help build future educators' necessary skills for teaching and learning. Additionally, educators in contemporary teaching systems should not only convey content knowledge; they should also possess skills in learning process analysis, misconception identifications, and instructional decision-making. In teacher professionalism, competency in calling is a must. Regarding teacher professionalism, diagnostic competence is necessary. This is defined as teachers' abilities to clearly understand their students' knowledge, abilities, and learning challenges to provide the correct instructional feedback. Moreover, pedagogical diagnostic competence is described as the teacher's ability to provide pedagogical guidance (instructional feedback). For instance, pedagogical diagnostic competence comprises a variety of skills, especially the ability of teachers to accurately evaluate the novice learning of pupils, discern instructional support, and exercise pedagogical guidance. According to Artelt (2009), diagnostic competence is a central element of teacher professionalism and plays a significant role in improving the quality of teaching and learning processes in schools. Likewise, Busch and Leuders (2015) stated that for the planning and implementation of effective mathematics teaching, the ability to diagnose students' achievements and learning difficulties is an absolute necessity. Overall, the teacher's ability to modify their instructional practice to meet the needs of students, as well as to foster their understanding of a concept, is the focus of these competencies. When it comes to the



education of mathematics, students frequently give rise to erroneous beliefs and conceptual errors, and this is where the significance of diagnostic competence comes into play. Educators need to think about how to analyze errors in students' thought processes and the reasons for those errors to give the most relevant feedback. It has been studied and demonstrated that the ability to respond to the thought processes of the learners in the way that is most suitable to their level of understanding is the most significant factor that influences the outcome of the learners' performance (Philipp, 2018; McElvany, 2012). Teacher education programs are expected to be instrumental in building these competencies in prospective teachers. Engaging in the practicum, teaching pedagogy, and reflective practices helps future teachers learn to design appropriate teaching activities and identify students' difficulties in learning. A number of authors emphasize the importance of teaching prospective teachers the fundamentals of diagnostic assessment, error analysis, and pedagogical content knowledge to strengthen their diagnostic skills (Heinrichs & Kaiser, 2018; Prediger & Zindel, 2017). In the last few years, the focus of researchers has been on the possibilities of technological tools, as well as simulations and systems of diagnostics, to improve the diagnostic skills of teachers. The purpose of such approaches is to provide future teachers with the opportunity to assess students' learning gaps, analyze learning difficulties, and make adequate teaching decisions in a simulated learning environment (Schons, 2023; Wildgans & Scheuerer, 2020). Although a number of authors recognize the importance of diagnostic competence in teacher education, it has been established that prospective teachers still have difficulties in accurately understanding students' misconceptions and forecasting their learning. Therefore, it is necessary to analyse the extent to which teacher education programs are focused on developing diagnostic and prognostic skills of prospective teachers. The current trends and existing research gaps pertaining to diagnostic competence, prognostic competence, and teacher education programs have been illustrated and discussed by the current paper by analysing relevant and available research works.

Objectives of the Study

The present study aims to examine the existing literature related to diagnostic and prognostic competencies in teacher education. The specific objectives of the study are as follows:

1. To review the concept of diagnostic and prognostic competence in teaching and learning processes.
2. To analyse the role of diagnostic competence in mathematics teaching and learning.



3. To examine the diagnostic competence of prospective teachers as reported in previous research studies.
4. To explore the role of teacher education programs in developing diagnostic competence among prospective teachers.
5. To review the use of diagnostic tools, simulations, and assessment systems for enhancing teachers' diagnostic competencies.
6. To identify the research gaps in the existing literature related to diagnostic and prognostic competencies in teacher education.

Structure of the Paper

This paper has several sections. The background and objectives of the paper are given in the first section. The second section focuses on discussing what diagnostic and prognostic competence are in relation to the teaching and learning process. The other sections review the literature on diagnostic competence in teaching mathematics, diagnostic competence of pre-service teachers, and teacher education programs aimed at developing these competencies. The paper also reviews literature on the use of diagnostic tools, simulations, and assessments to improve teachers' diagnostic competencies. Finally, the paper concludes by addressing the research gaps identified in the literature review.

Concept of Diagnostic and Prognostic Competence

In the teaching profession, and especially in this age of modernization, the teacher needs to have a mixture of different pedagogical and cognitive skills, to comprehend different aspects of students' learning and behavioural demands. One of these skills, which have been of particular interest in the educational studies, is the so-called Diagnosing competence. Diagnosing competence refers to the teacher's ability to identify knowledge, abilities, misconceptions, and learning barriers of students in order to make sound and effective instructional choices. It is the ability to recognize learning and teaching phenomena in the classroom. A number of researchers have pointed to the importance of this skill in teaching and learning processes. Schrader and Helmke, (1987) pointed to this ability as the ability of the teacher to accurately assess the students' background so that the teaching and learning processes can be adjusted to the students' levels. Also Artelt (2009) reiterates the above assertion that, this competence is one of the hallmarks of a teacher, and that, she is instrumental in enhancing the teaching processes in a classroom. Competent teachers are the ones who are good at identifying students'



misconceptions and errors and providing the necessary constructive feedback to the students. When it comes to teaching mathematics, diagnostic competence is crucial since students often experience conceptual challenges and form misconceptions while learning different mathematical ideas. Teachers need to determine what students mean and how they think to help them resolve these issues. Wilson's (2005) work has shown how critical error analysis is for acquiring diagnostic competence in mathematics teaching. Likewise, Busch and Leuders (2015) stress the importance of diagnosing students' mathematics achievement formatively so that effective teaching can be designed and students' conceptual understanding can be improved. Another element that is concerned with diagnostic competence is that of prognostic competence. Prognostic competence is the ability of a teacher to foresee students' future learning advancement given their understanding and performance at that point. By means of prognostic judgments, a teacher is able to make appropriate instructional strategies, choose appropriate learning activities, and provide intervention to students who may be experiencing learning problems. Effective learning processes in the classroom are, as McElvany (2012) states, a result of the effective diagnosis of students' capabilities and the accurate assessment of the learning tasks' levels of difficulty. In the last couple of years, researchers in the field of education have started to place importance on the combination of diagnostic and prognostic competencies in teacher education. With these competencies, teachers can not only pinpoint students' learning gaps but undertake plans to counter these gaps so as to elevate students' academic levels. Therefore, among the many aims of teacher education, the cultivation of diagnostic and prognostic competencies in prospective teachers, is of utmost importance.

Diagnostic Competence in Mathematics Teaching

Teaching with diagnostic competence is essential in mathematics instruction because learners often grapple with certain conceptual difficulties and develop misconceptions while learning mathematical concepts. Learning mathematics is a significant cognitive undertaking and errors in learning stem from a misunderstanding of a fundamental principle of the concept. In this regard, teachers are faced with carefully analyzing students' inputs to ascertain the errors and provide the necessary guidance. Consequently, the ability to diagnose students' cognitive processes and learning challenges is a central pillar of the practice of teaching mathematics. The practice has received research attention and in mathematics classrooms, the focus has been on the teacher's diagnostic competence. Zaidi and Ali (2019) emphasized that for mathematics to be learned effectively, certain aspects of the teaching-learning process are fundamental, such as teacher preparation, pedagogical content knowledge, and misconceptions. They noted that teachers need to be diagnostically competent in unmasking students' misconceptions and guiding them through the appropriate teaching strategies. In the same regard, Busch



and Leuders (2015) noted that the ability to diagnose students' learning for the purpose of formative assessment is an important competency for the successful teaching of mathematics. There is also research that has been directed towards analyzing teachers' ability to diagnose students' mathematical thinking and errors. Takker (2012) analyzed teachers' understanding of students' mathematical thinking in relation to observations and interviews with teachers about specific classroom tasks. The study concluded that teachers can improve their pedagogical practices by analyzing student responses and reflecting on their thought processes regarding the students' response. Wilson (2005) similarly analyzed the cognitive ability to diagnose student errors in mathematics. The study highlighted the necessity for teachers to have both types of knowledge so that they can accurately diagnose the cognitive errors and omissions of students. Additionally, various researchers have stated the need for teachers to listen to the students' cognitive processes in order to make the appropriate cognitive diagnosis. Prediger and Zindel (2017) studied teachers' skills related to the diagnosis of students' mathematical thinking and concluded that teachers should be able to diagnose the different levels of student thinking in order to adequately assist the students' learning. All of this demonstrates that cognitive diagnostic competence is primarily associated with teachers' educational content knowledge, their understanding of the mathematics learning process, and their understanding of students' learning process. Also, other researchers have noticed that students' mathematical error is not necessarily indicative of their lack of understanding. For example, Ketterlin-Geller & Yovanoff (2009) studied diagnostic assessment approaches in mathematics and found that traditional methods like skills and error analysis identify performance but fail to reveal deeper cognitive processes, whereas Cognitive Diagnostic Assessment (CDA) provides better insight into students' thinking and supports effective instructional decision-making.

This underscores how important it is for teachers to look past the marks and methodically assess the students' conceptual understanding before they can assist the learning progression. Overall, current literature indicates that bounded diagnostic competence is of critical importance for the teaching of mathematics. Teachers who have the capacity to breakdown the students' thought processes, detect misconceptions, and understand learning barriers can custom design instructional interventions that elevate the students' understanding of mathematics.

Table 1 Summary of Studies on Diagnostic Competence in Mathematics Teaching

Author(s)	Year	Focus of Study	Key Findings
Zaidi & Ali	2019	Mathematics teaching and learning issues	Effective mathematics learning depends on pedagogical content knowledge, identifying



			misconceptions, and proper teacher preparation.
Busch & Leuders	2015	Diagnostic competence in mathematics functions	Formative diagnosis of students' achievement is essential for planning effective mathematics instruction.
Takker	2012	Teachers' understanding of students' mathematical thinking	Analysing students' responses and reflecting on their thinking helps teachers improve instructional practices.
Wilson	2005	Error analysis ability in mathematics	Teachers need conceptual and procedural knowledge to interpret students' errors accurately.
Prediger & Zindel	2017	Teachers' interpretation of students' mathematical reasoning	Understanding different levels of students' mathematical thinking is essential for effective diagnostic judgment.
Ketterlin-Geller & Yovanoff (2009)	2009	Diagnostic assessment approaches in mathematics education	Traditional methods limited; CDA improves understanding and instructional decisions

The above studies highlight that diagnostic competence plays a significant role in mathematics teaching, particularly in identifying students' misconceptions, analysing their thinking processes, and planning effective instructional strategies.

Diagnostic Competence of Prospective Teachers

The focus of the educational research in the past few years has been the diagnostic competence of prospective teachers. As a future practitioner, one of the roles of a teacher is to ensure that students' learning is the main focus of the teacher. Prospective teachers also need to be trained to analyze students' responses, pinpoint the misconceptions, and explain the students' learning processes. Research has shown that integrating these skills into teacher education is, on the other hand, a very complex process, and one that is going to require some sustained effort. Several researchers have studied the diagnostic competence of prospective teachers in various educational settings. Lim (2021) studied elementary pre-service teachers' ability to make diagnostic inferences about students' understanding of the concept of fractions. Lim (2021) found that prospective teachers were, in fact, able to differentiate various levels of understanding, however, posed challenges in the construction of appropriate diagnostic assessment tasks that would tap into students' conceptual understanding. Reinhold (2018) also studied the pre-service



teachers' critical and reflective diagnostic strategies while conducting one-on-one mathematical interviews with first-grade students. Findings showed that, while not sufficient, some of the activities and training courses in the area of diagnostics, can result in a considerable change in the way prospective teachers analyse students' responses and the quality of the diagnostic strategies they develop. In prospective educators, research has acknowledged the strengthening of diagnostic competence through pedagogical content. Ostermann (2018) noted that one aspect of building pedagogical content knowledge is the ability to adopt students' viewpoints and understand the extent of their knowledge. Ostermann found that prospective teachers' diagnostic judgments about the difficulty of a task can be enhanced through pedagogical content knowledge and task-specific instructional support. Additionally, Heinrichs and Kaiser (2018) analysed the impact of university courses on future teachers' diagnostic competence regarding students' errors during the learning process. Their results argued that university education has an impact on how future teachers understand students' errors and how they address them instructional. They found that having practical teaching experience is better for diagnostic competence. Overall, the research shows that while prospective teachers have an understanding of the subject matter, they need a lot of training and practice for developing diagnostic competencies. Therefore, teacher education institutions need to provide prospective teachers a lot of opportunities to understand students' thinking, diagnose the learning problem, and adjust teaching strategies in the actual class situation.

Table 2 Summary of Studies on Diagnostic Competence of Prospective Teachers

Author(s)	Year	Focus of Study	Key Findings
Lim	2021	Diagnostic inference of pre-service teachers about students' understanding of fractions	Prospective teachers could identify levels of understanding but faced difficulty designing diagnostic assessment items.
Reinhold	2018	Diagnostic strategies of pre-service teachers in mathematical interviews	Structured diagnostic training and courses improve prospective teachers' diagnostic strategies.
Ostermann	2018	Diagnostic judgments and pedagogical content knowledge	Teaching relevant PCK can significantly improve prospective teachers' diagnostic judgments.
Heinrichs & Kaiser	2018	Development of diagnostic competence in error situations	University courses and practical experience help prospective teachers understand and respond to students' errors.



Prediger & Zindel	2017	Diagnostic competence in interpreting students' mathematical thinking	Prospective teachers must recognize different levels of students' reasoning to support learning effectively.
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The studies presented above indicate that diagnostic competence among prospective teachers can be developed through structured training, pedagogical content knowledge, and practical teaching experiences provided during teacher education programs.

Role of Teacher Education Program

Educational institutions for teachers are essential in developing the skills necessary for the practice of effective teaching. These institutions prepare future teachers in areas of content knowledge, teaching methodologies, and student learning. Of the various skills expected of teachers, the ability to diagnostically assess learning has recently become more critical. As a consequence, the teaching institutions aim to provide future teachers with the opportunities to develop the skills that will enable them to identify learning problems of students and to address them with suitable instructional responses. The importance of teacher education programs in nurturing diagnostic competence has been previously documented. An example is Abdullayeva's (2017) work that studied the university environment and the development of diagnostic competence and stated that the organisation of university psychological and pedagogical courses is of significance. She pointed out that the development of the students' psychosocial understanding of the students' learning behaviours is a result of her systematic educational psychology training. This is the same case for Schwarz (2008) who studied the teacher training programmes and the development of professional competencies of future mathematics teachers. This research is also part of the international comparative project focused on the mathematics teaching and learning. Schwarz observed that within the teacher's professional competence, diagnostic competence is a significant precursor faculty. Given this, she called for teacher education programmes to include potential evaluation activities in order to foster the ability for students to critique and elaborate on the reasoning underpinning gaps in the framework of students' solutions. This has also been the case in studies that have documented the growing evidence of the educational competencies, which include teacher Pedagogy diagnostic competencies. This is also true for the case of Tordova (2021) in which the establishment of pedagogical competencies, including diagnostic, through the integration of theory and practice is noted. This is a true reflection of the educational programmes that provide teachers with the necessary competencies and pedagogical practice to manage a myriad of classroom challenges. Galustyan (2018) noted that teachers' strategies towards control and diagnostics matter while managing an



educational process. With sufficient training, educators can learn to assess student achievement, measure progress, and pivot technically. In a similar vein, UNESCO (2006) noticed the need for teaching diagnostics and the value of measuring achievement, comprehension, and/or understanding before, during, or after teaching to increase the stimulant value of teaching and learning. Diagnostics in teaching is an emerging area in educational literature and for this reason, teacher education is important in developing prospective teachers' diagnostic competence. In this regard, the integration of theory, pedagogy and practice in teacher education programs, equip teachers with the competencies to diagnose the learning problems of students and design suitable learning activities.

Table 3 Summary of Studies on the Role of Teacher Education Programs

Author(s)	Year	Focus of Study	Key Findings
Abdullayeva	2017	Development of diagnostic competence in university environment	Psychological and pedagogical courses help in developing diagnostic abilities of future teachers.
Schwarz	2008	Diagnostic competence in mathematics teacher education	Teacher education programs help prospective teachers evaluate students' solutions and reasoning.
Tonova	2021	Educational competencies of teachers	Teacher education programs develop complex professional competencies required for teaching.
Galustyan	2018	Diagnostic activities in teaching	Teachers' diagnostic activities support effective management of the educational process.
UNESCO	2006	Diagnostic teaching in classrooms	Teachers should assess students' understanding before, during, and after instruction.

The studies presented above highlight that teacher education programs play an important role in developing diagnostic competence among prospective teachers through theoretical knowledge, pedagogical training, and practical teaching experiences.

Diagnostic Tools, Simulation and Assessment



The last few years have seen a rise in educational research around diagnostic tools, simulation, and evaluation systems, particularly toward helping teachers improve their diagnostic skills. These systems allow teachers and future educators a chance to review and analyse the responses of students and the misconceptions they have, and as a result, make thought out instructional choices. Perhaps in large part due to the proliferation of technology, developed environments for simulation and assessment have also proven effective in focusing on areas of concern for diagnostic skills within the scope of teacher training. Schons (2023) examined the application of simulation-based environments for assessing some of the possible diagnostic skills of teachers in mathematics education. The study illustrated that within a simulation environment teachers can isolate and interpret different responses from students and make diagnosis decisions. While the design incorporated scaffolding to support teacher's outcomes, it minimally impacted how teachers viewed the simulation. The study provided support for future development of simulation-based diagnostic training. Likewise, Wildgans and Scheuerer (2020) created a simulation-based computer environment for the assessment and promotion of diagnostic activities of prospective teachers. Heitzmann (2019) also noted that instructional design based on simulation holds promise for enhancing diagnostic competence in both medical and teacher education. The study suggested an interdisciplinary approach to research on designing simulations that assist learners in acquiring the skills necessary for analysing multifaceted contexts and making precise diagnostic evaluations. Beyond simulation exercises, diagnostic assessment instruments have been extensively utilized in assessing teachers' capacities to discern student learning obstacles. Yaghmour (2016) studied teacher competence in designing diagnostic tests for students in the primary school cycle and noted that teachers exhibited moderation in the extent of their competency in formulating such tests. The study underscored the urgency of the need for additional endeavors directed toward the acquisition of training on diagnostic assessment. Moreover, computerized tools for intervention have been designed to aid students' learning and to provide teachers with diagnostic information concerning students' learning. Gonzalez (2016) designed an integrated dynamic representation (IDR) system to assist in the enhancement of students' competencies in mathematics and the ability to solve mathematical problems. Such instruments facilitate teachers' ability to realize students' progress and to identify obstacles in the learning process. The literature suggests that the fusion of technological instruments, simulation exercises, and diagnostic assessment systems are of immense value for the improvement of teachers' diagnostic skills. These methods offer ways for educators to investigate the learning processes of the students, understand assessment results, and, through evidence, determine the appropriate instructional strategies to implement.

Table 4 Summary of Studies on Diagnostic Tools, Simulation and Assessment

Author(s)	Year	Focus of Study	Key Findings
Schons	2023	Simulation for assessing diagnostic competence	Simulation environments provide authentic contexts for Analysing students’ responses and developing diagnostic skills.
Wildgans & Scheuerer	2020	Computer-based simulated environment	Simulation-based environments can effectively assess and promote diagnostic processes of prospective teachers.
Heitzmann	2019	Simulation design for diagnostic competence	Instructional simulations can support the development of diagnostic competencies in education.
Yagmour	2016	Teachers’ skills in preparing diagnostic tests	Teachers showed moderate competence in designing diagnostic tests, indicating the need for further training.
Gonzalez	2016	Computerized intervention tool (IDR)	Technology-based tools help in identifying students’ learning difficulties and improving mathematical competencies.
Karvonen	2014	Diagnostic assessment systems	Diagnostic assessment systems provide detailed information about students’ achievement and learning progress.

These studies indicate that technological tools, simulations, and diagnostic assessment systems play an important role in strengthening teachers’ diagnostic competencies by providing structured opportunities to analyse students’ learning processes and interpret assessment data.

Summary Table of 36 Reviewed Studies

Author(s)	Year	Focus of Study	Key Findings
Schons	2023	Simulation for diagnostic competence	Simulation environments help assess teachers’ diagnostic skills.
Lim	2021	Diagnostic inference of PSTs about fractions	Prospective teachers struggle in designing diagnostic assessment items.
Tonova	2021	Educational competencies	Teachers require complex professional



		of teachers	competencies.
Wildgans & Scheuerer	2020	Computer-based simulation	Simulation environments help assess diagnostic processes.
Heitzmann	2019	Simulation-based diagnostic training	Instructional simulations support diagnostic competence development.
Zaidi & Ali	2019	Issues in mathematics teaching	Pedagogical content knowledge and teacher preparation are crucial.
Binder & Krauss	2018	Diagnostic competence (COACTIV project)	Diagnostic skills influence students' mathematical achievement.
Biza & Zachariades	2018	Diagnostic competence in teaching situations	Teachers must diagnose classroom situations effectively.
Galustyan	2018	Diagnostic activities in teaching	Diagnostic activities help manage the educational process.
Heinrichs & Kaiser	2018	Error diagnosis in teaching	University courses influence teachers' diagnostic competence.
Ostermann	2018	PCK and diagnostic judgments	Pedagogical content knowledge improves diagnostic judgments.
Ostermann & Leuders	2018	Students' perspectives in teaching	PCK improves teachers' ability to judge task difficulty.
Philipp	2018	Diagnostic competence and learning	Diagnostic competence supports students' learning success.
Reinhold	2018	Diagnostic strategies of pre-service teachers	Structured courses improve diagnostic strategies.
Abdullayeva	2017	Development of diagnostic competence	Psychological and pedagogical courses help develop competence.
Prediger & Zindel	2017	Interpreting students' mathematical thinking	Teachers must recognize different reasoning levels.
Yaghmour	2016	Diagnostic test preparation	Teachers show moderate skill in diagnostic test preparation.
Gonzalez	2016	Computerized intervention tool (IDR)	Technology helps identify learning difficulties.

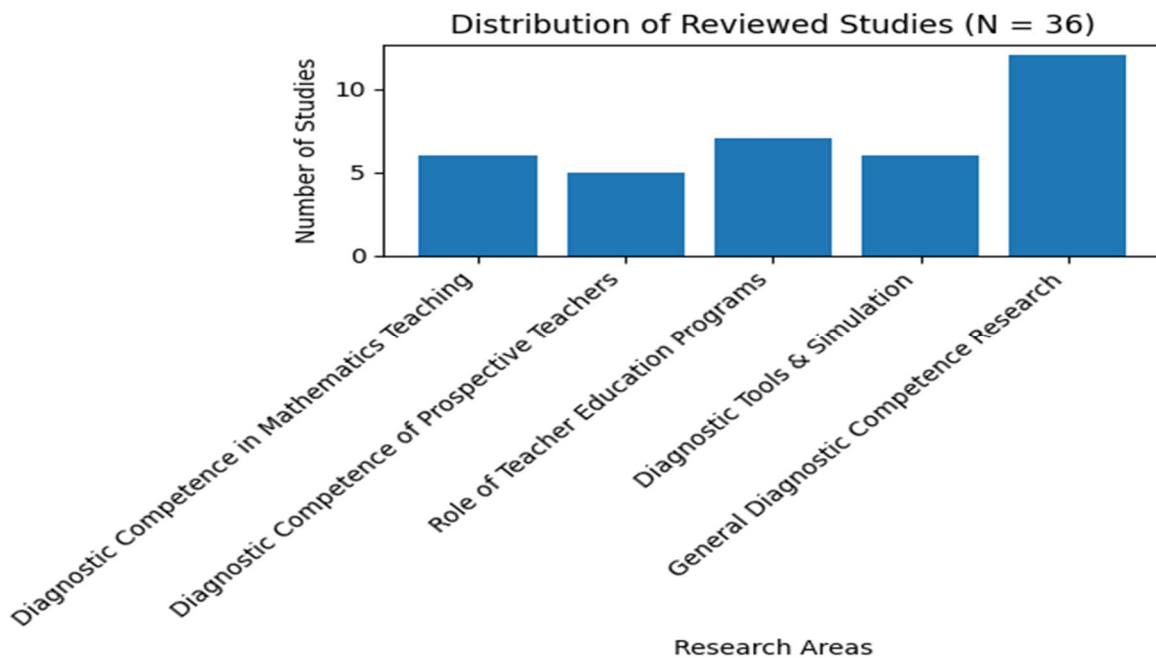


Busch & Leuders	2015	Diagnostic competence in mathematics	Formative diagnosis supports effective mathematics instruction.
Ohle & McElvany	2015	Teacher diagnostic judgment	Diagnostic competence is important in heterogeneous classrooms.
Gulevska	2015	Teacher–student relationship	Emotional aspects influence teacher competence.
Violeta & Aneta	2015	Teacher competence comparison	Teacher education programs need improvement.
Philipp & Leuders	2014	Teachers’ diagnostic judgments	Accuracy of teacher judgments is important.
McElvany	2012	Judging task difficulty	Teachers must estimate difficulty of learning materials.
Takker	2012	Students’ mathematical thinking	Analyzing thinking improves teaching strategies.
Hardy	2011	Diagnostic classroom activity	Helps adapt teaching during lessons.
Artelt	2009	Teacher professionalism	Diagnostic competence is a core element of professionalism.
Helmke	2009	Diagnostic judgments in teaching	Helps adapt teaching to students’ needs.
Ketterlin-Geller & Yovanoff (2009)	2009	Diagnostic assessment approaches in mathematics education	Traditional methods limited; CDA improves understanding and instructional decisions
Schwarz	2008	Teacher education programs	Teacher education develops diagnostic competence.
Ophuysen	2006	Teacher experience	Experience improves diagnostic accuracy.
UNESCO	2006	Diagnostic teaching	Assessment before, during and after teaching is important.
Spinath	2005	Teacher judgment accuracy	Diagnostic competence is multidimensional.
Schwerdt & Rummer	2005	Expert teachers	Experienced teachers make more accurate judgments.



Wilson	2005	Error analysis ability	Conceptual and procedural knowledge required.
Brown	1978	Diagnostic modelling system	Explains causes of students' mathematical errors.
Karvonen	2014	Diagnostic assessment systems	Provide detailed information about student achievement.

Graph: Distribution of Reviewed Studies (N = 36)



The chart illustrates how the studies reviewed in this paper are spread across four major research fields: competence diagnostics in mathematics teaching, competence diagnostics of future teachers, the influence of teacher education programs, and diagnostics and simulation-based method tools.

Research Gap

The existing body of literature suggests that while diagnostic competence has been the focus of a great deal of educational research, and specifically research in mathematics education, a number of publications have highlighted the need for research in the area of teachers' ability to identify a student's misunderstanding of a concept, the analysis of a student's response to a question, and the instructional adjustments a teacher needs to make in order to address a student's misunderstanding of the concept.



Specifically, literature has examined some of the components of diagnostic competence, such as the analysis of a student's error, the assessment of a student's understanding, and the analysis of the student's understanding of the mathematical construct. In reviewing the literature, a number of gaps and deficiencies in the literature were identified. First, for the majority of research that has been conducted on the understanding and value of diagnostic competence, much less research has been conducted on the understanding and value of the combined construct of diagnostic and prognostic competencies, in teaching. Some research suggests that while diagnostic competence allows educators to determine the learning challenges a student is facing and, prognostic competence gives educators the ability to anticipate the learning challenges a student is facing and the instructional approaches that should be used to address the learning challenges, the combined use of these two competencies has been investigated very little. Second, while some studies have investigated the gap in diagnostic competence of prospective teachers, the research suggests that a significant number of prospective teachers still struggle with the ability to accurately identify a student's misconception and the interpretation of a student's learning process. This suggests teacher education programs might not include sufficient opportunities to build prospective teachers' diagnostic competencies. Third, although many studies have addressed the role of teacher education programs in fostering professional competencies, research is scarce on the effects of teacher education programs in fostering prospective teachers' diagnostic and prognostic competencies. Most studies pay attention to teachers' professional competence in general, or focus on diagnostic competence only, neglecting the contribution of teacher education programs on the development of both diagnostic and prognostic competencies. Additionally, the most recent studies have examined simulation-based environments and other technologies for the enhancement of diagnostic skills.

Conclusion

The growing impact of diagnostic and prognostic competence in teachers' professional training reveals a critical area of concern in the literature. Teachers' jobs now extend beyond teaching the subject. Teachers need to know how to teach and how to guide students in their understanding of the content, and in particular how to identify and misunderstand the learning and make decisions. Competence in diagnostic describes a teacher's ability to examine the knowledge of students, the barriers to understanding, and the process of thinking, and prognostic competence describes a teachers' ability to predict future understanding of students and how to direct teaching towards instructional goals. The research indicates that diagnostic competence is critical to the teaching of mathematics, as students often have errors and gaps in their understanding of the concepts. Teachers who understand their students' work, who understand the errors, and who understand the thinking of students, are better able to teach. The literature



is consistent that the diagnostic competence is a reflection of the teacher's pedagogical knowledge and ability to empathize with students as active participants in the learning process. The literature is consistent that the diagnostic competence is a reflection of the teacher's content/pedagogical knowledge and ability to empathize with students as active participants in the learning process. Finally, the inability to identify the learning obstacles of students is widespread among teachers. Even with knowledge of the subject, teachers need instructional support to refine these diagnostic skills. Research on future educators indicates that analytic judgment ability can be improved by diagnostic training, structured activities, and teaching practicum. This potential for analytic judgment improvement also extends to the activities offered in programs for the preparation of future educators. Teacher training institutions encourage future educators to cultivate the ability to analyse the learning problems of students and respond adequately to the needs of the classroom. This is done by offering theoretical courses in pedagogy, psychology, and teaching practice. It has been established that the combination of theory and practice is a significant element in the enhancement of a teacher's professional competencies. The latest developments in instructional design also provide teachers with improved tools for diagnosis. Prospective educators have structured opportunities for the practice of analyses of student answers from various learning activity assessment tools through the use of simulations, computer-assisted diagnostic technologies, and digital assessment tools. The increasing use of these tools is likely to improve teachers' diagnostic competencies, yet the use of these tools in teacher education programs is still in the early stages.

Overall, teaching literature argues that if prospective teachers are taught diagnostic, prognostic, and other similar competencies, there will be a significant improvement in the quality of teaching and learning in the future. Therefore, teacher education programs need to incorporate systematic instruction, practical opportunities, and tech to strengthen these competencies. These competencies will help future teachers understand the student learning process, better handle learning misconceptions, and provide a more adaptive and beneficial instructional atmosphere.

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