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Integrating Rubrics as a Competencies-based Evaluation Tool for Performance Enhancement in Mathematics Education

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KEYWORDS Assessment Tools. Construction. E-Evaluation. Holistic Education. Learning. Pedagogy

ABSTRACT The field of education is rife with debate over the most effective methods to improve learning and performance among pupils. Educators from all over the world endorse the use of rubrics as a teaching tool today, highlighting the significant contributions that rubrics can make to the teaching-learning paradigm. A rubric is a helpful grading tool that educators may use to give more objective, dependable, and consistent grades. Students can become more aware of their strengths and limitations, and more objective about the ability of their work with the help of a well-designed rubric. The present study aimed to construct and validate competency-based rubrics for the mathematical problem-solving content of grade 8. The study was conducted in three phases: construction, validation, and implementation of the rubrics. The results revealed that students scored good marks after using rubrics, and teachers were also clearer about the assessment and scoring methods. It was also observed that if a rubric is developed, it may significantly improve student learning while also reducing the amount of time the instructor needs to spend grading papers. Thus, the rubric serves as an effective tool in the assessment of the students' performance in Mathematics. The researchers further provided the reflections given by the teachers in the present study and suggested the recommendations accordingly.

INTRODUCTION

Classroom instruction is designed to influence pupil behaviour in a desirable direction. This desired direction is determined by the educational objectives established by the school and the teacher. The teacher must, first of all, be aware of what is the purpose and aim of education. More precisely, the instructor must create instructional objectives for distinct lessons and units in a subject's reorganised and systematised syllabus. Second, based on student learning and good communication channels, the instructor should be able to build effective learning experiences. Finally, the instructor will assess the degree to which these goals have been met. Hence, three major elements in the education process are objectives, learning experiences, and learner appraisal as shown in Figure 1.

Objectives are the goals that someone has for how they want people to act. The word 'learning experiences' refers to the things that learners do and go through to learn how to act in the right way. The purpose of learner evaluation is to figure out how well the goals have been met. So, one can say that judging or evaluating a learner is a very important part of the teaching and learning process. Learning helps with setting goals, planning learning situations, and judging how well a learner did. Aside from that, it is a great way to improve teaching and education. It lets society, parents, and the school system know who is responsible for what.

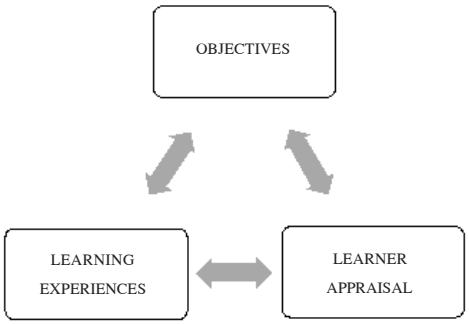

Fig. 1. Showing major elements in the education process

Assessment as Envisaged in NEP 2020

The NEP 2020 anticipates a shift away from summative assessment towards frequent and formative assessments that are competency-based, support learning and growth, and test

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higher-order abilities like analysis, critical thinking, and conceptual clarity. Pupils will take tests by authorised authorities in grades 3, 5, and 8, while revamped board exams for grades 10 and 12 will emphasise holistic development. A new National Assessment Centre, PARAKH, will be developed as a standard-setting authority, and the National Educational Technology Forum (NETF) will encourage the use of technology to improve learning, assessment, planning, and administration. In collaboration with NCERT, SCERTs, teachers, and experts, the National Council for Teachers Education will create National Professional Standards for Teachers (NPST) by 2022. The NEP reorients the approach of appraising lower divisions by replacing memory examinations with comprehensive evaluations. The undergraduate credit system will boost confidence by allowing students to earn credentials and re-enroll as needed, with credits stored in an Academic Credit Bank. The assessment model will measure the application of knowledge, and the report card will provide a continuous and comprehensive evaluation. Universities will have a common entry test possibly given by the National Testing Agency (NTA). A National Assessment Strategy with a well-defined assessment architecture will be created to improve learning while maintaining faith in exams. In conclusion, the NEP 2020 is a groundbreaking initiative to advance the educational system (Table 1).

Rubric: An Assessment Tool

The word "rubric" was first used in the middle of the 15th century by Christian monks who copied holy texts, with big red letters at the top of each main section of the book. The primary components of the book names were referred to as rubrics since the Latin word for red is a rubric. Educators, on the other hand, have given the word a new meaning in the last few decades. They now use the word 'rubric' to mean the standards they use to judge the work or performance of their students. Rubrics are useful tools for marking because they make assessments more reliable, valid, and clear (Silvestri and Oescher 2006). They are frequently employed in order to make reviews more objective and less subjective. They are frequently utilised in the classroom for descriptive writing, class projects, and presenting oral speeches.

Teachers seldom use rubrics to assess short-answer, multiple-choice, or true/false tests. They are mostly used to evaluate how well a student did on a performance-based test, like writing an essay about a certain subject that persuades the reader. Performance tests are made to see how well a student knows how to do certain things that teachers think are important to learn and teach. Most teachers do not tell their students what the expectations are for their tests. Teachers often think that their students will be able to do a great job on their own. This assumption, though, often leaves teachers disappointed when they find out that students are not doing well or that their grades are getting worse. Rubrics can help teachers tell students what they are expected to do by giving them evaluation standards that can be used to grade. Students can figure out if their work is good, very good, excellent, or bad with the help of rubrics. Students can benefit from a well-designed scorecard by receiving constructive criticism, learning about frequent errors, and receiving further information on how to enhance their work. Studies have been conducted that demonstrate the benefits of utilising rubrics when teaching. These studies have demonstrated that students learn more and perform better as a whole when rubrics are implemented in the class-

Table 1: Showing various types of assessment tools

Type	*Assessment tools*
Formative Assessment Tools	Quizzes and Tests, Observations, Exit Tickets, Peer and Self-Assessments, Interactive Activities, Digital Tools, Portfolios, Journals and Learning Logs
Summative Assessment Tools	Standardised Tests, Final Exams, Projects and Presentations, Research Papers, Performance Assessments, Portfolios, Rubrics
Diagnostic Assessment Tools	Pre-Tests, Diagnostic Tests, Interviews and Conference
Tools for Both Formative and Summative Assessments	Rubrics, Checklists, Surveys and Questionnaires

room. Numerous studies (Chowdhury 2019; Jonsson and Svingby 2007; Silvestri and Oescher 2006) have shown that rubrics can make tests more accurate and clearer. Some teachers think that rubrics are great ways to tell students what is expected of them and to grade their writing work. Some people, though, say that rubrics are too strict, not reasonable, and do not help students improve their writing. These people who do not like rubrics say that they can lead to a standard way of judging student work. Wilson (2007) says that there are good things about writing. Wilson (2007) says that each piece of writing has its own set of rules, so teachers should carefully look at each one. Kohn (2006) says that rubrics should never be used as a way to teach because that could make students' work less thought-out instead of more so.

Important Characteristics of Rubrics

Criteria: A good scorecard will have a clear list of criteria so that students know what the teacher is looking for.

Gradations: There should be different levels of quality based on how well a standard has been met. This is basically the same thing as a scale. There should be clear explanations of what 'excellent', 'good', 'fair', and 'needs improvement' mean. Each level of success should be described by its grade. A rubric usually has four to six sets of grades. Rubrics that work well use a lot of words to describe things. The rubric spells out in detail what makes a good task. By being specific, the descriptors help students check and understand their numbers.

Continuity: The difference in quality between a score of 5 and a score of 4 should be the same as the difference between a score of 3 and a score of 2. All of the descriptors should show the same amount of continuity.

Reliability: A 'good' rubric should allow different teachers to use it and come up with similar scores for the same task. Reliability can also mean time. For example, if you are grading your 100th essay, you can use the same criteria you used for your first essay to grade the 100th essay.

Validity: A valid rubric grades what is most important to the performance and task, not just what is easy to see and easy for the teacher to grade.

Models: Remember to show examples of goods at different levels of success. Make sure to keep the models' identities secret.

Review of the Literature

Mathematical education depends much on rubrics as they provide organized assessment criteria and improve teaching strategies. Multiple rubrics have been created to target certain facets of teaching and learning mathematics, making it easier to evaluate teachers and measure student achievement. Chowdhury (2019) studied the definition of a rubric, the range of rubric types that may be used in the classroom, the creation process, the advantages of employing rubrics, and other research findings. Teachers can offer better feedback and help students learn by using rubrics.

A design-based research study by Loong et al. (2018) refined the reasoning rubric assessment using instructors' knowledge. 510 teachers who were confident in their mathematical reasoning felt that a summative rubric would be more useful, but the detail in the rubric was helpful for teachers who needed more training in developing student reasoning and reporting student progress. The study by Takagi and Nikami (2018) found that rubrics can increase education and aid teachers' work. This study showed that rubrics help students study since they can see the goal and their current topic mastery.

Tekin Dede et al. (2017) introduced a cognitive modelling rubric called the 'Rubric for the Assessment of Modelling Skills', and explained its creation. Understanding, simplifying, mathematising, working mathematically, interpreting, and validating comprise the rubric. The study included 6^{th} graders and 11^{th} graders. The study analysed participants' modelling tasks and created dimension levels throughout 10 weeks of data collecting. The rubric evaluates and scores modelling task implementation solutions.

Miknis et al. (2020) investigated whether self-assessment rubrics promote student learning. Higher education computer programming students had to self-assess using the same rubric as the assessors. Existing research supports the relevance of revisiting feedback for both assessors and students.

Tobon et al. (2020) designed and validated an analytical rubric for elementary school leaders to self-assess and enhance learning. 645 primary school principals found every item satisfactory, relevant, intelligibly expressed, and useful for improving their managerial practices. A factor analysis revealed a single factor, as expected theoretically. Finally, the rubric has 0.877 dependability. Management practises self-assessment rubric content, construct, and dependability are satisfactory.

Mustafa and Raisha (2021) tested a rubric for the assessment proposed by Mustafa et al. (2019) based on student responses. A questionnaire assessed student satisfaction with rubric marks for each category and the total passing grade. It also examined whether students' rubric grades matched their expectations. These test learners' mathematical reasoning practices and provide feedback to instructors to help them understand and encourage learners' reasoning progress (Rohati et al. 2022).

Berciano et al. in 2024 created and validated a rubric that addresses key parts of an early childhood education teacher's teaching job (teaching role, children's responses, mathematical relationships, and resources), allowing for a comprehensive and justified analysis of teaching practice. Further, Jen Hua Ling (2024) explored research on rubrics, concentrating on learning facilitation, fair evaluation, dependability, and validity. The goal was to provide a balanced view of the proper usage of rubrics. The study suggested that if rubrics are used, they should be well-designed, implemented, and constantly updated. Otherwise, an alternative strategy for achieving educational objectives should be developed.

Significance of the Study

Students today need to know more than just how to read and do maths. They must also navigate an ever-changing world, analyse, draw conclusions, and think critically. As the required skills and knowledge evolve, so must learning goals, impacting how assessment and teaching interact. Teachers should participate in setting assessment goals and determining what is tested. Gibbs (2010) outlines six main purposes of assessment, that is, capturing students' attention and time, promoting effective learning methods, providing timely feedback, helping students grasp field standards and equality, differentiating students with marks or scores, and offering external proof of course standards. Diverse assessment tools, beyond standard exams, can foster active learning, teamwork, and peer learning, and monitor real-time progress. Rubrics are particularly effective, aiding teachers, students, and parents by clearly outlining expectations and offering specific feedback on strengths and areas for improvement, thus guiding student progress. Rubrics are also integral to the NISHTHA Integrated Teacher Training Programme, based on NEP 2020, which emphasises comprehensive and school-based assessment. However, studies indicate that teachers lack sufficient knowledge of rubrics and their application in Maths classes. Hence, the researcher conducted a study to educate teachers on creating and effectively using rubrics to enhance Maths assessments.

Objectives of the Study

The objectives of the present study were:

1. To construct an effective rubric as an assessment tool in Mathematics.
2. To validate a rubric as an assessment tool in Mathematics.
3. To find out the suggestions given by the teachers of Mathematics about the effective usage of a rubric.
4. To provide recommendations to the educators and policymakers for effective usage of rubrics as an assessment tool.

MATERIAL AND METHODS

In the present study, the researchers developed a rubric for a pie chart or circle graph of class 8th in Mathematics, which was developed in three phases. Each of these three stages' processes are discussed in depth as illustrated in Figure 2.

First Phase (Construction Of The Rubric): A preliminary version of the rubric was created in the first phase based on the requirements that the assignments or scripts given to the students must meet.

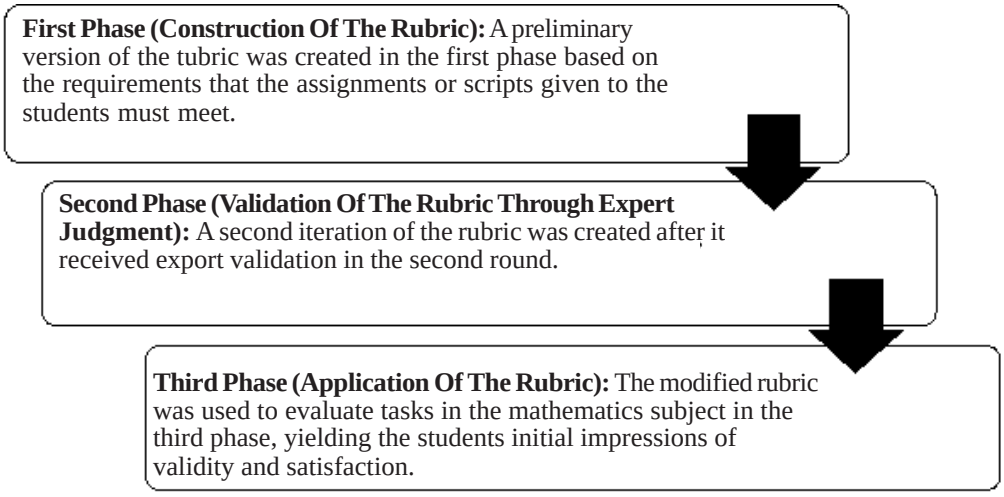

Fig. 2. Showing three phases of research methodology of the study

Second Phase (Validation Of The Rubric Through Expert Judgment): A second iteration of the rubric was created after it received expert validation in the second round.

Third Phase (Application Of The Rubric): The modified rubric was used to evaluate tasks in the mathematics subject in the third phase, yielding the students' initial impressions of validity and satisfaction.

First Phase: Construction of the Rubric

Content analysis is the first step in the process of making a tool. Content analysis is a tool or method for doing a study that is often used to look at content and its parts. It is a way to turn personal information into useful information by sorting data and comparing different pieces of information. In the present study, the investigator before constructing the rubric has done the content analysis. The content analysis was done for the NCERT book of Mathematics subject of class 8th. The investigator has taken the topic 'Pie Chart or Circle Graph' in the chapter 'Data Handling'.

Rubric for Assessing a Mathematics Research Study

As a plan for developing the rubric, the researchers chose the topic 'Pie Chart or Circle Graph' in the chapter 'Data Handling' from grade 8's Mathematics curriculum. The rubric was constructed by the following steps.

1. General framework
2. Selection of the different criteria to be taken. In this rubric, the criteria taken included conceptual understanding, representation of data, computation and procedure, accuracy, and reflection and evaluation.
3. Elaborating these criteria according to the pie chart concept.
4. Following the establishment of the criteria, the levels of achievement for each item, its score, and the descriptors of each level were defined.
   In this rubric, the levels taken were emerging, developing, proficient and exemplary. These are taken in increasing order of the students' achievement, that is, 'emerging' level is the lowest achievement and 'exemplary' is the highest level of achievement. Scores were given according to the level of achievement of the students.
5. Describing the various levels of achievement according to the pie chart concept.

The first version of the rubric was made in the form of a 5 x 4 matrix.

Second Phase: Validation of the Rubric Through Expert Judgment

Validation is a quality check that ensures assessment system judgments are valid. A proper

assessment indicates a learner has all the skills and information in a training product. Individual aggregation was utilised to validate the first rubric using expert judgement. In this approach, each assessor received the material individually without contact (Bowen et al. 2022).

In the present study, the initial version of the rubric was validated by:

- Peer Experts
- Language Expert
- Supervisor
- Expert in Mathematical Sciences

The experts sent their evaluations of the rubric via email, the experts' contributions were analysed to reconstruct the rubric, and their contributions were added. This reformed version of the rubric was ready for testing on the students of grade 8 of KV School Rahya.

Third Phase: Application of the Rubric

The rubric was used in group work carried out by students from grade 8 at KV School Rahya after it was changed based on the experts' opinions and validation. With the permission of the school's principal and the concerned teacher, the researchers took an online class to clear the concept of the pie chart. After that, the researchers took an online evaluation of the students. Students were allowed to send their answer sheets in PDF form.

The researchers took the evaluation of 20 students in grade 8 and marks were given according to the self-made rubric.

Data Analysis and Interpretations

Keeping in view the objectives of the study, the researchers have used the mean and correlation for data analysis.

From Table 2, it is observed that the students have a high mean value in question number 9 and a low mean value in question number 1. This means that students scored high marks in question 9 and scored low marks in question 1. Thus, one can say that question 9 was easy and question 1 was difficult for the students to understand.

From Table 3, it is observed that criteria 4 has a high mean value and criteria 2 has a low mean value. This means that students face more difficulty in the 2nd dimension of the rubric.

Table 3: Showing the mean of the various criteria formed in the rubrics

Criteria	*1*	*2*	*3*	*4*	*5*
Mean	4.725	2.5	4.4625	5.95	3.45

From Table 4, it is observed that the various competencies of the rubric have high correlation values, thus making it an effective tool for the assessment.

RESULTS AND DISCUSSION

This research adds to the expanding body of data showing that rubrics are an effective tool for enhancing learner results and assisting educators with the assessment process. Rubrics can improve teaching and learning processes by encouraging self-regulation and transparency. However, the full potential of rubrics can only be achieved via thorough training, which ensures their reliability and validity while also adapting them to different learning situations.

Table 2: Showing the mean of the scores of the answers obtained from the students

Question	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Mean	0.525	0.7125	0.7125	0.775	0.6	0.65	0.75	0.975	1

Table 4: Correlation between various competencies of the Rubric

Correlation b/w	*Criteria 1*	*Criteria 2*	*Criteria 3*	*Criteria 4*	*Criteria 5*
Criteria 1	1	0.836217	0.925695	0.941025	0.924935
Criteria 2	0.836217	1	0.963647	0.954323	0.693992
Criteria 3	0.925695	0.963647	1	0.993177	0.845994
Criteria 4	0.941025	0.954323	0.993177	1	0.877407
Criteria 5	0.924935	0.693992	0.845994	0.877407	1

Exploration of Key Findings

The study highlights the role of rubrics in enhancing student performance, particularly in Mathematics, as evidenced by the topic on 'Pie Charts' for Grade 8. The data reveal that students excelled in certain areas (high mean score for question 9) but struggled in others (low mean score for question 1). This aligns with the premise that effective rubrics make both strengths and weaknesses clear, enabling targeted feedback for improvement (Chan and Ho 2019). Rubrics promote self-regulation in learning, which is increasingly recognized as a critical skill in educational growth (Fitriyani et al. 2024).

Rubrics are key tools for self-assessment in educational settings, improving students' grasp of performance requirements and encouraging self-regulated learning. According to research, rubrics not only define learning objectives but also increase the accuracy of self-assessments, ensuring that student ratings match teacher expectations. According to Krebs et al. (2024), students who used rubrics showed a greater comprehension of quality characteristics in their work, which resulted in more informed modifications. In the present research, students could see their weaker areas and work on improving them, which suggests that rubrics not only assess but also guide the learning process toward better outcomes.

Explanation of Rubric Utility

The rubric's competencies-conceptual understanding, representation of data, computation and procedure, accuracy, and reflection and evaluation-play a crucial role in breaking down complex mathematical concepts like Pie Charts into manageable learning objectives. The high correlation values across these competencies, as indicated in the study, reinforce rubrics' effectiveness as an objective and consistent assessment tool (Chowdhury 2019).

Moreover, rubrics provide both teachers and students with clear expectations, enabling more focused feedback. As per the study of Behera (2024) rubrics assist teachers in maintaining consistency in grading assignments and students by standardizing assessment criteria, (Behera 2024). This aligns with the findings from the present study, where rubric use enabled consistent evaluations, thereby supporting academic standards.

Elaboration on Critical Aspects

Despite their proven benefits, rubrics come with challenges, particularly in terms of training, reliability, and validity. According to Cano (2015), teachers must be adequately trained to use rubrics effectively. Without this training, rubrics may lose their potential to foster self-regulated learning and to create a visible learning environment. The necessity for reliability and validity checks is underscored, as rubrics must be robust enough to fairly evaluate diverse competencies across different learning scenarios.

Rubric development is also time-consuming but once made can reduce the educators' burden significantly. In addition to outlining objectives, rubrics help with feedback, which is crucial for student development and self-learning in the classroom (Campos and Ferreira 2024). The findings from this study support this view, showing that rubrics reduce the grading burden while maintaining the quality of feedback and student learning.

However, Eltanahy and Mansour (2024) caution against the over-standardization of rubrics. While rubrics promote consistency, they may stifle creativity and restrict flexibility in assessment. This concern was partially reflected in this study, as some students found the rubric-driven assessments too rigid, which limited their ability to explore alternative solutions in mathematics. Therefore, rubrics need to strike a balance between structure and flexibility to cater to diverse learning styles.

Evaluation of Rubric Effectiveness in Learning

The results from this study underscore the effectiveness of rubrics in improving student performance and fostering deeper learning in Mathematics. The high mean values for specific competencies suggest that students, when provided with clear assessment criteria, are better able to focus their efforts and achieve higher levels of understanding (Fitriyani et al. 2024). Furthermore, students reported that rubrics made learning more transparent and helped them set clearer learning goals.

However, the use of rubrics remains debated. While rubrics promote self-regulation and help students assess their progress, Eltanahy and Mansour (2024) point out that some students may feel constrained by the rigid nature of rubrics, which can limit creative problem-solving. In light of these critiques, rubrics should be designed with enough flexibility to allow for student expression while still maintaining a structured assessment framework.

Additionally, as the findings suggest, rubrics can highlight areas of weakness, but they are not a one-size-fits-all solution. Teachers must adapt rubric criteria to the needs of different learners, ensuring that the feedback provided is both actionable and relevant (Chowdhury 2019). This adaptation is crucial for ensuring that rubrics remain a dynamic tool for learning rather than a static measure of performance.

The findings highlight the importance of balance—rubrics must offer enough structure to ensure fair assessment while remaining flexible enough to encourage student creativity and individual learning paths. With these considerations in mind, rubrics can continue to evolve as a critical tool in modern education, fostering both accountability and autonomy in learners.

Educational Implications

Let Students Know What to Expect: Rubrics help teachers clearly define their expectations by establishing precise criteria, detailing what students need to achieve specific grades, and clarifying unwritten standards like citing sources to avoid plagiarism.

Offers Knowledgeable and Timely Feedback: Rubrics provide detailed feedback on strengths and weaknesses, allowing teachers to give immediate, comprehensive insights into student performance and areas for improvement, thereby speeding up the grading process.

Supports Fair Evaluation and Consistent Grading: Rubrics ensure consistent grading, even when teachers are fatigued or under pressure, by providing a standard method. This transparency and efficiency in grading promote fairness and reduce grading time.

Encourages Students to Learn and Evaluate Themselves: Rubrics serve as teaching tools that foster student engagement and self-assessment. By using rubrics, students can set learning goals, track their progress, and evaluate their own work, enhancing their writing, critical analysis, logical reasoning, and creative thinking skills.

Encourages Peer Assessment: Rubrics get students to think about how they think and maybe even how they decide what is 'good'. They also get them to look at their work and process to see if it meets the standard that the rubric explains. Students can also evaluate their friends' using rubrics, which makes peer assessment more interesting and useful.

Feedback for Parents: Parents like rubrics because they help teachers explain why a certain grade was given to their child. Rubrics are easy to figure out just by looking at them. They give parents a review that is easy to understand, short, and well-organised. Parents like that a rubric gives them detailed comments.

Reflections by Teachers

Teachers provide valuable feedback regarding the usage of rubrics in pedagogy. They believed that rubrics act as a valuable tool for swiftly, consistently, and fairly assessing student work. A rubric can help students identify their areas of strength and weakness but teachers treat a rubric more time-consuming. Moreover, some teachers said a rubric provides a thorough assessment of a student's performance at each stage of development. It provides opportunities for pupils to upgrade their learning to the next level. Also, it helps learners pay closer attention to the questions. Some teachers suggested more descriptions might help to make the rubric more effective. Some highlighted the difficulty of creating a rubric for each topic in a course, particularly in mathematics.

CONCLUSION

Rubrics are utilised as an instructional aid in a range of areas in the classroom, and yet, the number of instructors who use rubrics remains small. Although the use of rubrics in grading various performance-based activities is becoming more widespread, many teachers are still unaware of their numerous advantages. A well-crafted rubric may also improve a student's educational experience greatly. With the use of ru-

brics, students may conceptualise their learning objectives and track their progress. This essay explains and develops the use of rubrics as a tool for evaluating student performance in mathematics problem-solving. Furthermore, rubrics make it easy for teachers to judge if a student's work is great, ordinary, or in need of development. Teachers may be hesitant to utilise rubrics in the classroom at first because they might consume important time. However, if a rubric is developed, it may significantly improve student learning while also reducing the amount of time the instructor needs to spend grading papers.

RECOMMENDATIONS

To enhance performance in mathematics education through the integration of rubrics as competencies-based evaluation tools, it is essential to develop clear and comprehensive rubrics aligned with curriculum standards, involving all stakeholders in their creation. Therefore, the key step is to provide professional development for teachers and incorporate rubrics into daily instruction. Rubrics should be used for both formative and summative assessments, encouraging self-assessment and peer assessment among students to promote reflective learning. Also, the regular reviews and updates of the rubrics can ensure their relevance while leveraging technology can streamline the assessment process. It is also recommended that monitoring and evaluating the impact of rubrics, will inform necessary adjustments, and fostering a growth mindset culture will emphasise progress over grades. Lastly, promoting collaboration and sharing of best practices among educators will further enhance the effectiveness of rubrics in improving student performance in mathematics.

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