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Key Features and Selection Criteria of Mathematical Activities: Perspectives of Teacher Educators and Teachers

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Abstract: This study aims to explore the key features of mathematical activities and the criteria valued in their selection from the perspectives of mathematics teacher educators and teachers. Designed as a qualitative study, data were collected through four focus group discussions conducted both online and face-to-face with 22 participants, including 10 teacher educators and 12 teachers selected via criterion sampling. The transcripts were analyzed using a two-stage coding process. In the first stage, open coding was applied to examine the data line by line and generate initial codes. In the second stage, axial coding was carried out to relate codes, construct categories, and organize them around the research questions. Coding was conducted independently by two researchers and verified through expert review to ensure reliability. The findings reveal both commonalities and distinctions between the two participant groups. Both teacher educators and teachers emphasized the importance of activities being goal-oriented, clearly structured, supported with accessible materials, and fostering active student participation. However, teacher educators highlighted dimensions such as didactic quality, conceptual depth, collaborative learning, and contextual richness, whereas teachers focused more on practical applicability, classroom management, workload balance, and the inclusion of assessment components. These results suggest that teacher educators tend to prioritize design principles and the quality of the learning process, while teachers emphasize classroom functionality and practical considerations.

Keywords: Mathematical activity, Mathematics education, Mathematics teacher educators, Mathematics teachers

Introduction

One of the fundamental objectives of mathematics education is to ensure that classroom activities are conducted in a purposeful and effective manner (Agac, 2018). In this regard, various learning and teaching approaches have come to the fore, one of which is activity-based teaching (Bozkurt et al., 2023). A mathematical activity is a learning situation structured by purpose, content, representation, and expected actions, aiming to engage the student with a specific mathematical idea (Doyle, 1983; Smith & Stein, 1998; Ohtani & Watson, 2015). The current ICMI 22 study frames activity design as both the clear definition of learning objectives and the construction of cognitive/epistemic opportunities that lead to these objectives. It highlights the necessity for activities to address not only "what will be done" but also "why and how it will be done" (Watson & Ohtani, 2015). In other words, it is crucial that the activity be designed in a thoughtful and intentional manner. There is a growing body of evidence indicating that activity-based teaching produces tangible outcomes, such as positioning students as active subjects of the learning process, supporting lasting learning and achievement, and creating technology-enhanced environments for exploration and discussion (Çelik, 2018; Deringöl et al., 2021;

Freeman et al., 2014). However, the nature of the activity is not determined solely by design principles; the micro-decisions taken by the teacher implementing the activity in the classroom, the ways in which cognitive demands are maintained or expanded, and contextual adaptations directly determine the nature of learning (Henningsen & Stein, 1997; Stein et al., 1996). Studies showing how high-cognitive-level tasks are transformed in the classroom indicate that the cognitive demands of the task can be reduced or maintained during implementation (Henningsen & Stein, 1997). Therefore, the literature suggests focusing on the co-production relationship between design (purpose, usability, representation) and implementation (intended pedagogies, teacher decisions) (Sullivan et al., 2015). Furthermore, design approaches that base activities on the principle of purpose and usefulness (the learner understanding why the activity is valuable) have become widespread (Ainley et al., 2006).

Studies conducted in many contexts, including Turkey, mostly describe the design principles of activities or report their educational benefits (Bingöballi & Özmantar, 2009; Watson & Ohtani, 2015; Sullivan et al., 2013; Çelik, 2018; Gürbüz et al., 2010). In contrast, a direct empirical study systematically comparing the criteria for a "successful activity" between teacher educators and teachers was not found in the literature review; the existing body of work is largely centred around common design examples and general design principles, emphasising the need for further empirical research in this area (Jones & Pepin, 2016; Watson & Ohtani, 2015; Kieran et al., 2015). This gap necessitates a systematic exploration of the relationship and potential tensions between the theoretical attributes of an activity and the criteria for its selection and application in the classroom (Jones & Pepin, 2016). The aim of this study is to examine the characteristics that mathematical activities are required to possess and the dimensions that are important in their selection, thereby contributing to filling this gap through a comparative analysis of teacher educators' and teachers' perspectives. In line with this purpose, the study seeks to answer the following research questions:

- What characteristics do teachers and teacher educators attribute to a successful mathematical activity?
- What dimensions do they consider important when selecting an activity for classroom implementation?

Method

This study, aiming to examine the characteristics that mathematical activities are required to possess and the dimensions that are important in their selection, has been designed using a qualitative research method. Focus group discussions, one of the qualitative data collection techniques, were used in the study. Focus group discussions involve individuals selected from a specific population focusing on a predetermined topic and sharing their views on that topic (Barbour & Schostak, 2005). In this regard, mathematics teacher educators and teachers with experience in activity design and implementation were interviewed for this study. The interviews aimed to identify the characteristics of a successful activity and the important considerations in selecting activities.

Participants

Table 1. Participant selection criteria

Mathematics Teacher Educators	Mathematics Teachers
• Having at least one article on activities published in a peer-reviewed journal • Having authored at least one book chapter on activities in an edited volume • Having supervised at least one postgraduate thesis on activities • Having presented at least two papers on activities at national or international conferences • Having authored at least one textbook prepared for use in schools affiliated with the Ministry of National Education (MoNE) • Having taught an undergraduate methodology course such as Special Teaching Methods or Mathematics Teaching	• Being a graduate of an Elementary Mathematics Teacher Education program in a faculty of education • Currently working as an active mathematics teacher in a secondary school affiliated with the Ministry of National Education (MoNE) and teaching classes • Using concrete materials in mathematics teaching and being able to share examples of such materials • Having used virtual manipulatives or software developed for mathematics teaching and being able to share examples of their classroom use • Using activities in mathematics teaching and being able to provide examples of the activities used • Having participated in at least one project conducted by MoNE or TÜBİTAK with an activity developed together with students

A criterion sampling approach was employed in selecting the sample for the study. In this regard, a key criterion was having either academic research or direct practical experience in mathematical activities. Participants were selected on a voluntary basis; during the selection process, they were required to meet at least two of the criteria specified in Table 1, and priority was given to candidates who met more of these conditions. In line with these criteria, 10 mathematics teacher educators (MTE) and 12 mathematics teachers (MT) with experience in activity design or implementation were included in the study. Thus, the study was conducted with a total of 22 participants. The identities of the participants were kept confidential; mathematics teacher educators were assigned codes such as MTE1, MTE2 while teachers were assigned codes such as MT1, MT2.

Data Collection

The research data was collected through separate workshops conducted with MTEs and MTs. Two workshops were organised, one online with five participating teacher educators and one face-to-face with another five. Similarly, data was collected in two sessions with 12 participating secondary school mathematics teachers, of whom five participated online and seven participated face-to-face. In the focus group discussions, participants were asked:

- What characteristics do you think a successful activity should have?
- When selecting an activity, what characteristics do you pay attention to and think are important to consider?

All responses were analysed, and explanations related to the research topic were compiled. This provided an opportunity to examine participants' views on the characteristics a quality activity requires, as well as the similarities and differences in these views.

Data Analysis

The data for this study consists of transcripts from four focus group discussions conducted with mathematics teacher educators and teachers. The discussions, conducted both face-to-face and online, were collected into two separate data pools: one belonging to mathematics teacher educators and the other to mathematics teachers. Data analysis was performed using a two-stage coding process in line with the approach of Strauss and Corbin (1998). During the first stage, open coding was used to examine the data line by line and convert meaningful statements into codes. In the second stage, axial coding was performed; similar codes were linked to form categories, which were then structured around the research questions.

The coding process was conducted independently by two subject matter experts; the codes were then compared to develop a common code book. The process was reviewed in a validation session involving four subject matter experts, including two coders, and consensus was reached on controversial points. In terms of validity and reliability, the recommendations of Özmantar and Batdı (2020) were taken into account; participant selection criteria, data set, analysis process and findings were presented in detail, findings were supported by evidence-based quotations, coder reliability was utilised, and the process was also validated by expert opinions.

Results

The data obtained within the scope of this study were examined in general terms and comparatively for each participant group. The findings of the analyses are presented in Table 2, Table 3 and Table 4, respectively. Table 2 reveals that the responses of MTE and MT highlight some common highlights and differences regarding the structural components of the activities. Both groups agree that the activities are supposed to serve the defined purpose, the instructions to be clear and understandable, the materials to be economical and easily accessible, and the students to actively participate in the process.

However, MTE focused more on the didactic nature of the activities, highlighting aspects such as the sequence of instructions, suitability for students' entry skills, functionality and reusability of materials, and the provision of collaborative learning environments. They also emphasized the importance of students producing a mathematical output at the end of the activities. MTs, on the other hand, have focused more on classroom practicality, highlighting points such as achievement-orientedness, instructions that lead to the goal, materials appropriate to the students' level, reducing the teacher's workload while increasing student responsibility, and clarifying individual or group roles.

Table 2. Structural components of the activities

Cat.	Code	MTE	MT	Description
Aim	Serving for the purpose	√	√	*"... does the activity lead to its intended purpose? (MTE1)"*
	Being outcome-oriented		√	*"When I take the activity, will it provide the desired outcome? (MT1)"*
Instructions	Having well-structured instructions	√		*"The teacher needs to structure these instructions properly... they need to be arranged in an orderly way. (MTE3)"*
	Being clear, concise, and understandable	√	√	*"... the instructions given must be consistent, understandable, and should not contain large gaps. (MTE1)"*
	Leading to the goal		√	*"The instructions should not deviate from the activity's goal. (MT2)"*
	Not having gaps between instructions	√		*"... we are trying to guide the student from here to there... we need to take them step by step. In some activities, the gap between two instructions is so large that cognitively... the student cannot handle it. (MTE1)"*
	Addressing students' entry skills	√		*"... it should address the students' entry skills as well. (MTE1)"*
Materials	Being well-planned	√		*"... the proper planning of the activity's tools and materials is important. (MTE1)"*
	Using different materials	√		*"... incorporating different materials... adds value. (MTE4)"*
	Being reusable	√		*"(materials) should be reusable. (MTE4)"*
	Being economical	√	√	*"Is the material truly cost-effective? Can it be easily obtained, and can I quickly create it in the classroom? (MT1)"*
	Being accessible	√	√	*"... the material should be easily accessible. (MTE1)"*
	Being functional	√		*"But the context in which the material is used in the activity is also important. Is it just being used as an attention-grabbing tool? ... If you're using fraction cards, are they used for mathematics, or just for verifying mental operations? I prefer the former. (MTE1)"*
	Being appropriate for student level		√	*"The appropriateness of the material depends on the general class situation. (MT1)"*
Responsibility	Ensuring active participation	√	√	*"The student will be fully involved in the process. We will give them questions that will keep them mentally awake. (MTE5)"*
	Reducing teacher workload while increasing the student's		√	*"If I'm going to conduct the activity, it should significantly reduce my workload, ideally to zero. I give the child a task... At least during the activity, my workload should be minimized, so that when I look back, I can say 'oh'. I want the children to be fully engaged in it. (MT6)"*
	Having teacher and student roles well-defined		√	*"Also, the instructions for the teacher and student roles are not clearly defined. The instructions are written for the student, but what will the teacher do during the process? (MT5)"*
	Include a work format (group-work, pair-work, etc.)		√	*"In most activities, it doesn't specify whether the work will be individual or collaborative. It doesn't say whether the student will work alone or in a group. (MT5)"*
	Including collaboration and group work	√		*"For me, it's important to provide collaborative learning. If all students can contribute... Group work is important for me, if possible. (MTE4)"*
Output	Producing a mathematical output	√		*"If the activity keeps the mind awake with continuous questions and, in the end, results in a product, I consider that activity to be a good one. (MTE5)"*

Table 3 reveals that the definitions of MTE and MT highlight some common foci and differences based on pedagogical/functional conditions. Both groups agreed that activities need to be appropriate for the class level, inclusive of all students, designed to suit the learning environment, realistic in terms of feasibility, and engaging and motivating for students. Furthermore, both sides emphasized that the fun aspect of the activities would facilitate students' focus on the lesson.

Table 3. Pedagogical components of the activities

Cat.	Code	MTE	MT	Description
Inclusivity	Ensuring appropriateness for the class level	√	√	*"I check whether it is appropriate for the class level, whether the class can do it or not. (MT7)"*
	Addressing all students	√	√	*"I prioritize making sure every student can participate. If I am going to implement the activity, every student must participate. (MT8)"*
	Including familiar contexts for the students	√		*"There are sometimes socio-economic factors involved... They ask metro-related questions sometimes. Now, when you use this in a setting where some students have never seen a metro, they can't relate to the context. (MTE4)"*
	Providing different starting points	√		*"Different starting points... Some might start from step A, while others could start from step C or D, for example. (MTE4)"*
	Addressing various areas (affective, cognitive, etc.)		√	*"I want it to address multiple aspects—whether emotional, cognitive, or psychomotor... Sometimes examples include activities like coloring while also solving a puzzle, or achieving the intended learning outcome while also gaining something else, like emotional or cognitive benefits. (MT6)"*
Timing	Using time efficiently	√		*"Time and efficiency are very important. Time management is critical in the activity... Maximizing the benefits obtained during that time is crucial. (MTE4)"*
	Avoiding excessive time consumption		√	*"Especially, the most important thing for me is whether it takes too long. I try to avoid activities that take too much time due to their intensity, as I want to focus on activities that can achieve learning outcomes more efficiently. (MT7)"*
	Specifying time in the activity text		√	*"In most cases, the process is not given, meaning the activity is provided but the duration is not stated. The minutes are not written. (MT5)"*
Physical Environment	Ensuring the learning environment is appropriate	√	√	*"The environment should be appropriate for the activity. Which space will this activity be used in? Will it be inside or outside the classroom? (MTE4)"*
Applicability	Ensuring the activity is applicable	√	√	*"... we need to ensure that it is applicable in the classroom. (MT3)"*
Flexibility	Ensuring the activity is adaptable	√		*"Should an activity be adaptable? That means it should allow for modifications or updates... (MTE8)"*
Motivation	Engaging and motivating the students	√	√	*"While discovering this information, the student should enjoy doing it... Oh, is that how it is? The exclamation is important. Oh, really? (MTE3)"*
	Making the activity fun	√	√	*"The activity should make the lesson more enjoyable... Yes, it should increase the fun factor so that the students focus more on the lesson. (MT8)"*
Assessment	Including evaluation questions at the end of the activity		√	*"When the activity is finished, there is no assessment or evaluation. We do the activity, finish it, but we don't check if the student can solve similar problems afterward. (MT5)"*
Classroom Management	Ensuring the activity is suitable for classroom management		√	*"Does it disrupt classroom management? Because when you implement the activity, you may notice that some students get distracted and move away from the activity. Then, the activity is not achieving its main goal, and we end up working with only three or five students. (MT4)"*

However, MTs placed greater emphasis on dimensions that deepen inclusivity, such as considering contexts familiar to students and offering different starting points, as well as planning elements such as efficient use of time and adaptability of the activity. MTs, on the other hand, focused more on issues encountered in the direct implementation process, such as not taking too much time, specifying the duration of the activity in the text, addressing affective-cognitive diversity, adding assessment elements, and suitability for classroom management.

Table 4. Mathematical content components of the activities

Cat.	Code		MTE	MT	Description
Mathematical Richness	Conceptual Depth	Structuring cognitive demand well	√	-	"The teacher should structure the cognitive demand within the activity appropriately... (MTE1)"
		Enabling discovery	√	-	"A good activity... should facilitate discovery... I expect the activity to be more focused on discovery... (MTE3)"
		Leading to generalization	√	√	"In activities... the effort to reach a generalization should be direct, aiming for full generalization (MT11)"
		Deepening learning	√	-	"If there's an activity in the book, it should engage other related knowledge from the book and deepen it. (MTE4)"
		Offering mathematical thinking and experience	√	-	"It's about presenting mathematics in a way that students can experience it. They need to meaningfully experience key mathematical concepts. (MTE6)"
		Highlighting the importance of mathematics and making it meaningful	√	-	"It's always important for me that the activity emphasizes the significance of mathematics and gives it meaning. (MTE4)"
		Including and developing different mathematical skills	√	-	"While discovering this knowledge, the student should also develop various mathematical skills... it's essential for fulfilling their curiosity. (MTE3)"
	Contextual Richness	Relating to real life	√	-	"It should be related to real life... one of the major challenges in mathematics is that students fail to connect concepts with their real-life equivalents. (MTE4)"
		Having a context	√	-	"There's also the content dimension... Is it created within a context? This isn't mandatory, but if created, it may attract more interest. We should check if the context aligns with mathematics. (MTE1)"
	Mathematical Clarity and Accuracy	Being free of errors	√	√	"There shouldn't be any scientific errors... (MT10)"
		Not causing conceptual misunderstandings	-	√	"Some activities really lead to conceptual misunderstandings... For example, when students are asked to find the LCM of 3 and 4, they think it's just the product of the numbers, which is a conceptual misunderstanding. (MT12)"
Selective Mathematical Focus	Focusing on difficult-to-comprehend concepts		-	√	"I pay more attention to activities for difficult-to-understand topics, for example... (MT9)"
	Addressing the key point of the topic		-	√	"Since I can't cover everything, I try to use the most critical, pinpointed activities... that's why I prefer more focused activities, whether short-term or long-term. (MT13)"
	Relating to mathematical events		-	√	"For example, Pi Week—there's great excitement around it. During that week, activities related to Pi might be introduced. It aligns with the week, the learning objective, and catches students' attention. (MT4)"

A careful examination of the findings in Table 4 reveals that MTEs and MTs have different perspectives on the mathematical content dimension. MTEs emphasized the conceptual depth dimension in particular; they stressed that activities need to involve high cognitive demands, encourage discovery, lead to generalization, deepen learning, enable students to experience mathematical ideas, convey meaning to mathematics, and develop different mathematical skills. They also stated that activities need to be related to real life and presented within a context under the dimension of contextual richness.

The MTs, on the other hand, did not directly emphasize these dimensions; they focused more on mathematical clarity and accuracy and selective mathematical focus. They stated that activities need to be error-free, not lead to misconceptions, be used especially for difficult-to-comprehend topics, address the most crucial points of the subject, and be related to mathematical days.

Discussion

Participants' responses regarding the characteristics that a quality activity requires and the aspects considered in its selection were found to be grouped around three main focuses (structural, pedagogical, content-related). This indicates that participants evaluate activities not only in terms of structural components (such as aims, instructions, materials, responsibilities); pedagogical functionality (such as inclusiveness, time management, classroom environment, motivation, assessment) and mathematical content (such as conceptual depth, contextual richness, accuracy, selective focus). This trend largely aligns with approaches in the literature that emphasize the multidimensional nature of activities. For example, while Doyle (1983) considers the structural and pedagogical dimensions of activities as regulatory frameworks for learning.

Silver and Stein (1996) and Kieran (2019) have demonstrated that the meaning of activities depends not only on design principles but also on classroom implementation and teacher–student interactions. Similarly, Radmehr (2023) emphasizes that mathematical activities cannot be limited to structural components alone; they have a layered structure that includes inclusivity, cognitive demands, and affective-social dimensions. When all these are considered together, it is seen that activities are not limited to structural components such as purpose, instructions, and materials; they also encompass pedagogical functionality and mathematical richness that guide students towards learning.

It has been determined that participating teachers place greater emphasis on practical criteria when defining the characteristics of a quality activity. Accordingly, it was considered important for activities to be success-oriented, contain clear and purposeful instructions, use materials appropriate to the student level, balance the teacher's workload and increase student responsibility, have clear student-teacher roles, have clearly defined time frames and avoid time-consuming activities, be consistent with classroom management, include assessment elements, and prevent misunderstandings. These results are consistent with the literature. For instance, Bozkurt et al. (2024) and Kılıç-Oduncu (2025) reported that teachers emphasized criteria such as classroom management, material appropriateness, clarity of instructions, and effective use of time as critical criteria in their activity implementation. Similarly, Tırabzon (2023) revealed that teachers evaluated their activity selections and implementations based on multidimensional factors such as preparation level, time management, material use, communication, and physical conditions.

These common findings suggest that teachers prioritize criteria of classroom applicability and pedagogical functionality because these factors directly influence the day-to-day dynamics of teaching and learning. Teachers are often confronted with the practical realities of diverse classrooms, where time constraints, varying student abilities, and classroom management challenges shape their decision-making. As a result, it can be said that teachers tend to perceive activities that are easily adaptable to the classroom environment, require manageable levels of preparation, and are designed to meet the needs of all learners as more effective.

Participating teacher educators focus not only on structural components but also on didactic quality and the nature of the learning process when selecting and designing a high-quality mathematics activity. In this regard, the criteria highlighted by educators include activities that present a high level of cognitive demand, guide students towards discovery and generalization, enable mathematical thinking and experimentation processes, develop different mathematical skills, and offer meaningful contexts related to real life. These findings indicate that teacher educators tend to evaluate activities not merely as technical tools that fill the teaching process, but rather in terms of their ability to create meaning in students, stimulate thinking, provide conceptual depth, and integrate content with context. Highlighting the creative potential of mathematical tasks, Vale and Barbosa (2024) emphasize that tasks are not only for conveying content but rather need to be seen as learning tools that support students' thinking processes, creativity, and meaning-making.

Similarly, the EDGA tool developed by Bozkurt et al. (2023) draws attention to the need to evaluate activity design beyond its formal characteristics, focusing on its supportive aspects of the learning process. Therefore, when the findings and related studies are evaluated together, it can be said that teacher educators tend to evaluate activities primarily based on their potential to enrich the learning process and support students' meaning-making process. In sum, it can be said that teachers tend to focus more on practical aspects of activity design, while teacher educators highlight the cognitive and didactic elements of the activities. One possible explanation for these differences in perspective lies in the distinct roles and responsibilities of teachers and teacher educators. Teachers, being directly involved in the day-to-day execution of lessons, may view activities through a more practical lens, considering factors like time management, classroom dynamics, and student engagement as immediate priorities.

In contrast, teacher educators, who are often more removed from the immediate classroom context, may adopt a more theoretical approach, focusing on how activities can enhance students' understanding of mathematical concepts, promote higher-order thinking, and contribute to the development of broader pedagogical skills. Furthermore, teacher educators may have more flexibility in exploring the idealized aspects of teaching and learning, whereas teachers must reconcile these ideals with the realities of diverse classroom environments.

Conclusion

Research findings reveal that participants' views on quality mathematics activities revolve around three main dimensions: structural, pedagogical, and content-related. In this regard, teachers focused more on criteria related to classroom applicability and pedagogical functionality such as achievement-orientedness, time management, classroom adaptability, and assessment; while teacher educators emphasized criteria highlighting didactic quality and the nature of the learning process such as cognitive demands, conceptual depth, and contextual richness. Therefore, the findings of this study reveal both teachers' sensitivity based on practical reality and teacher educators' expectations for deepening learning. This situation highlights different but complementary perspectives in the evaluation of quality mathematics activities.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* The authors declare that they comply with all ethical rules during the data collection and reporting process of the article.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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