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THE IMPACT OF TEACHERS' GENDER, EDUCATION, AND EXPERIENCE ON FOSTERING MATHEMATICAL CREATIVITY: A QUANTITATIVE STUDY

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Abstract. Mathematics education increasingly embraces creativity as a necessary element in the growth of students' problem-solving and critical-thinking skills. This study investigates how teachers' demographics (including gender, educational level, and experience) influence their practices in promoting students' mathematical creativity (MC) in Palestinian eighth- and ninth-grade classrooms. A questionnaire of teachers' creative teaching practices was used to collect data in a quantitative approach. The analysis found notable variations in these practices by teachers' gender, academic degree, and experience. Creative teaching methods were more common among female teachers, teachers with bachelor's degrees, and more experienced teachers. The findings identified teaching practices associated with each level of the demographic factors, thereby pinpointing the specific type of targeted professional development needed to promote MC. Moreover, the interaction between education level and teaching experience highlighted the nuanced interplay that shapes pedagogical practices. Emphasizing teacher demographics in these findings reveals new possibilities for promoting MC while offering valuable insights into teacher training and curriculum development.

Keywords: fostering mathematical creativity; mathematical creativity; mathematics teaching practices; professional development

1. Introduction

1.1. Background

Palestinian education context

Creativity in mathematics education, which involves moving from concrete experiences to the abstract formation of processes – i.e., from

problem-solving to creative practice and vice versa – is gaining recognition worldwide as an important skill for students to generate, learn, and adapt to a fast-changing society (Riling, 2020). However, teaching practices, which are influenced by contextual and individual factors, often determine the extent to which creativity can be promoted by teachers. The context for this study is the Palestinian educators in East Jerusalem (EJ) and the West Bank (WB) region, where the educational system operates with sociopolitical and logistical constraints shaping teaching and learning. The Palestinian education system is fraught with political and logistical challenges, and that has resulted in the need for innovative teaching and learning strategies. One such framework is the hybrid learning model implemented by MOE, where learners are required to attend three days of in-person learning alongside two days of online learning through Microsoft Teams 2 (Guzmán, 2021). But these innovations also highlight Palestinian teachers' underlying problems, including limited access to technology, intermittent student attendance because of political unrest, and the challenge of integrating traditional and modern teaching methods.

1.2. Statement of the problem

Though MC has been increasingly recognized as an important contributor to students' learning success (Wessels, 2017; Bicer, 2021), the common methods used by mathematics teachers to integrate creativity into their day-to-day teaching practices remain poorly understood (Kettler et al., 2018). The gap is particularly apparent in the Palestinian context, where unique sociopolitical and educational difficulties can impact teachers' capacity to promote creativity. This study seeks to address this gap in the literature by exploring how teachers' demographic factors predict their use of MC practices in eighth- and ninth-grade classrooms.

1.3. Rationale and purpose of the study

Creativity has emerged as an essential 21st-century skill, serving as both a driver of innovation and a means of addressing regional challenges (Schnugg, 2019; de Alencar, 2012). Creativity is related to problem-solving, intellectual development, and achievement for long-term development especially in mathematics education (Nadjafikhah, Yaftian, & Bakhshalizadeh, 2012; Suyitno, 2020). Creativity in mathematics — defined

as the capability to generate new and useful solutions to problems — is a fundamental component of students' mathematical competence and an important predictor of their performance in dealing with complex, real-world problems (Grégoire, 2016). However, the incorporation of creativity in the context of mathematics teaching remains largely unexamined, particularly in sociopolitical and educational contexts, in which restrictions on teachers' innovative practices may exist. Many students learn under varying modes of instruction due to the shortage of physical and human resources, the overload of curricular content, and the political instability of Palestine; therefore, the Palestinian education system provides a diversity to explore this phenomenon of teaching mathematics creativity. International studies have examined creativity in the context of the variables above, yet the outcomes of this research may not be generalizable to Palestinian teachers as cultural, political, and educational environments differ widely within this context. Additionally, previous research has primarily focused on higher education and has neglected to explore the mechanisms through which creativity is cultivated within schools, particularly in low-resource settings. To fill these gaps, this study investigates the teaching practices that foster MC in Palestinian eighth- and ninth-grade classrooms, as it explores the ways in which teachers' demographics inform their use of these practices. In the Palestinian context, it adds to the increasing literature about MC and holds practical implications for teacher training and curriculum development in similar contexts.

The study aims to make three key contributions to literature:

– Theoretical Contribution: It extends existing research on MC by examining its application in a unique and understudied context: Palestinian schools.

– Practical Contribution: It provides actionable insights for teacher training programs and curriculum development, helping educators adopt practices that enhance students' creative problem-solving abilities.

– Policy Contribution: It highlights how teachers' demographics shape their teaching practices and offers evidence-based recommendations for policymakers seeking to improve mathematics education in politically constrained environments.

Through these contributions, the study advances academic understanding of MC and supports the development of more effective and contextually relevant teaching strategies in Palestine and beyond.

1.4. Research questions

The main research questions are the following:

1. Does teachers' gender significantly influence their use of teaching practices that foster MC in eighth- and ninth-grade classrooms?
2. Does teachers' educational level significantly influence their use of teaching practices that foster MC?
3. Does teachers' seniority significantly influence their use of teaching practices that foster MC?
4. Are there significant interaction effects between teachers' educational level and seniority on their use of teaching practices that foster MC?

1.5. Importance of the study

This study can inform the design of teacher-training programs and professional development (PD) activities that promote the adoption of teaching practices that nurture students' MC. These programs ought to target and suit all teachers of various demographic features. Furthermore, the study's inspiration from eighth- and ninth-grade classrooms translates to practical recommendations that could be applied within curriculum development to ensure creative problem-solving is embedded early on in mathematics education. From a policy perspective, this study underlines the need to account for the demographics of teachers when designing educational interventions. The findings can help policymakers to target disparities in teaching practices so that students, regardless of their teachers' gender, education, or experience, can learn creative and engaging mathematics. Furthermore, the broader impact of this study may be to inspire similar research in other contexts – particularly those that are under-resourced or politically constrained – thus contributing to a more holistic and global understanding of MC.

2. Literature review

2.1. The importance of creative thinking in mathematics

Nurturing student creativity is an important part of mathematical thinking in education (Schoevers, Kroesbergen, & Kattou, 2018; Wessels, 2017). Since creative thinking in mathematics is fundamental in problem solving, innovation, and reasoning across disciplines, especially in the sciences (Escultura, 2012), it is indeed important. By fostering MC in students, and by getting them ready to solve complex, real-world problems, educators can boost not only their students' overall learning but also their intellectual growth.

2.2. Mathematical creativity: Exploration

Notably, although MC is widely recognized for its importance, there is still no universally accepted definition of it, and considerable debate remains over whether MC is an innate trait or a cultivated ability (Waswa & Moore, 2020; Kozlowski et al., 2019; Dickman, 2014).

A common understanding has emerged that MC involves the ability of scholars and professionals to generate new and useful solutions to problems, and that fluency, flexibility, and originality in thinking are key components of creativity (Levenson et al., 2018; Wessels, 2017). These three dimensions: fluency, flexibility, and originality, are considered essential in MC (Kozlowski et al., 2019; Molad et al., 2020). *Fluency*: being able to produce many correct solutions or strategies for the same problem (Meier et al., 2021; Tabach & Levenson, 2018). *Flexibility*: refers to the ability to come up with different solutions from different categories or approaches, showing adaptability in their thinking (Cox et al., 2024). *Originality*: The originality of the solutions refers to the fact that they are original or insightful and are not based on conventional solutions (Levenson et al., 2018).

2.3. Teaching practices that foster MC

In order for MC to happen in class we need to have innovative teaching methods that can push students to think critically and think about different ways of solving problems. Creativity in mathematics relates closely to skills

in producing new ideas and applying them in effective ways that pedagogical approaches can target (Byers, 2010; Barraza-García, Romo-Vázquez, & Roa-Fuentes, 2020). Some of these practices, highlighted in the literature, are:

Problem-Solving and Problem-Posing: Open-ended problems and creating their problems to solve encourages exploration and experimentation (Nadjafikhah, Yaftian, & Bakhshalizadeh, 2012).

Multiple Representations (MR): Externalizing abstract mathematical concepts through images, graphs, symbols, and drawings is essential for understanding in a creative way (Tversky, 2015).

Integration of Science, Technology, Society (STS): STS approaches allowing to connect mathematics to real-life contexts, while also fostering critical thinking, logical reasoning, and problem-solving abilities (Mulyanti et al., 2021).

Cooperative Learning and Digital Media: In addition, collaborative activities and the use of digital tools create conditions for the participant to work with different perspectives and innovative solutions (Kynigos & Moustaki, 2014; Miranda & Mamede, 2022).

2.4. The Influence of Teachers' Demographics on Their teaching practices

Demographic characteristics of teachers can have a strong impact on teachers' attitudes and practices toward nurturing creativity (Pazin et al., 2022; Kettler et al., 2018). Research indicates that teachers' pedagogical approaches and their capacity to foster a conducive atmosphere for creative thinking are shaped by gender, ethnicity, and years of experience (Kearns, 2019; Joklitschke et al., 2022). For example, previous research has revealed that teachers with higher academic qualification and female teachers are more likely to use student-centered and more innovative teaching methods (Rahimi et al., 2024). On another note, novice teachers might be more grounded in traditional practices, while experienced teachers might have established practices that help navigate challenges in creative ways. These demographic factors influence teaching practices, which are the focus of this study, with a view to providing new insights into teacher training programs and educational policymakers. This study aims to uncover strategies to

support Palestinian teachers in fostering MC in their classrooms in the context of the challenges of the local education system.

2.5. Previous studies

Many studies have suggested that several teachers' aspects, including their demographics, affect their teaching practices in the classroom. The researchers present here some of the studies related to the context of the current study.

2.5.1. Teachers' gender

Some studies have found no significant differences in teachers' attitudes toward classroom management or in fostering MC in class (Khodabandeh & Jamali, 2019). However, another study found that gender moderates the relationship between teachers' perceptions of principal and student prototypes and creative behavior (Zibenberg & Da'as, 2022). In addition, it has been indicated that teachers play a significant role in enhancing students' participation in classroom activities due to teachers' gender in favor of females (Alqaisi, 2010). Additionally, in another study, female teachers reported somewhat higher levels of teaching effectiveness and mastery approaches to instruction (Diwa et al, 2023). Several studies have shown that teaching practices that influence students' performance and creativity are more significant in Mathematics female teachers than those of male teachers (Zibenberg & Da'as, 2022).

2.5.2. Teachers' educational level and PD

Teachers' educational backgrounds, beliefs, and motivations significantly influence their approach to fostering creativity (Hong et al., 2009; Ayele, 2016). In addition, pre-service teachers, as well, have a moderate level of MC related to their academic achievement (Andrade & Pasia, 2020). Analogously, another paper has discussed how a graduate course facilitated mathematics teachers to recognize and foster MC in their classes through problem-posing activities (Moore-Russo et al., 2020). Other studies have highlighted that continuous PD programs designed for creative teaching strategies can efficiently improve teachers' competencies for promoting MC in their classes (Kandemir et al., 2019).

2.5.3. Teachers' experience

Some studies have found that more experienced teachers are more skilled, comfortable, and effective at designing and implementing teaching practices that foster MC (Kandemir et al., 2019). Other studies have found no significant difference between less experienced and more experienced teachers in fostering creativity in class (Shriki, 2010; Cayirdag, 2017).

2.6. Gap in literature

While previous studies have provided useful insights into the influence of teachers' gender, educational level, and experience on developing MC, some important gaps still exist.

First, evidence on whether teachers' gender matters is mixed. Some studies found no significant differences (Khodabandeh & Jamali, 2019), while others reported that female teachers had a stronger positive effect on students – first on creativity, and later on performance (Zibenberg & Da'as, 2022; Diwa et al., 2023). Hence, discrepancy warrants further investigation to elucidate the correlation between teachers' gender and their capacity to foster creativity in mathematics. Second, even though previous studies have looked at the relationship between teachers' educational degree and the PD they attend on the one hand, and the creativity they foster in their classrooms on the other (Hong et al., 2009; Moore-Russo et al., 2020; Kandemir et al., 2019); the bulk of that research has been conducted with pre-service or in-service teachers working in well-resourced contexts. However, how these factors work in conditions of scarcity or restriction, as in Palestine, where a unique set of conditions may shape teachers' practices is less understood. Third, the effect of teachers' experience on nurturing creativity is still controversial. Some studies show that experienced teachers are more effective in exploring creativity (Kandemir et al, 2019), while other studies indicate that differences in experience bear no significance (Shriki, 2010; Cayirdag, 2017). Such a difference highlights the necessity to examine if teaching experience intersects with other socio-demographic factors including educational attainment, to affect teachers' practices. Finally, most previous studies that explored MC have been conducted in Western or higher education contexts, with little understanding of MC development in school-level mathematics education in Palestine and other similar contexts. The current study aims to fill these gaps by exploring the impact of teachers'

demographics on the creative teaching practices performed by teachers in 8th- and 9th-grade Palestinian classrooms. Moreover, the study makes a significant contribution to the literature by addressing a unique and understudied context, offering insights that can be valuable in the domains of teacher training programs, curriculum development, and policy-making choices in Palestine and similar environments.

3. Methodology

3.1. Research design

Firstly, the researchers abstracted a quantitative research design through using a questionnaire to explore the teaching practices of Palestinian mathematics teachers in the eighth and ninth grades and to what extent these practices promote the students' MC. The items of the questionnaire were constructed after reviewing the literature to find items which had been shown to impact on teaching practices that promote creativity in the context of Mathematics education.

3.2. Participants and sampling

3.2.1. Study population and participants

The study's population is the Palestinian teachers who teach mathematics for eighth and ninth grades in Palestinian (public, private and UNRWA) schools in East Jerusalem and the West Bank. The participants were 240 mathematics teachers (65 male and 175 female) who volunteered from the population. These teachers were from three main regions: the Southern Governorates (Hebron and its surroundings), the Middle Governorates (Jerusalem, Jericho, Ramallah, and al-Bireh), and the Northern Governorates (Jenin, Tubas, Nablus, Tulkarm, Salfit, and Qalqilya). This variety in regions ensures fair representation of teachers from various geographical and socio-economic contexts.

3.2.2. Sampling process

The researchers aimed to have a well-dispersed and representative sample of Palestinian mathematics teachers because they are from various kinds of schools and from all governorates in Palestine. A stratified sampling method was applied, by splitting the population into homogeneous subgroups

(strata) according to school type (public, private, and UNRWA), and randomly selected schools from each stratum (Taherdoost, 2016). This method enhanced the accuracy of the sample and the interpretation of results.

3.2.3. Selection of teachers

Once schools were selected to participate in the study, the principals were invited to join the research study with an explanation of the research purpose and an invitation to participate voluntarily. Teachers who agreed to take part were sent a link to the online questionnaire. The final sample included 240 teachers (65 males, 175 females) from the three types of schools across the three mentioned main regions. Such a collection process allowed representation of teachers across different geographical locations and socio-economic backgrounds.

3.3. Summary of demographic characteristics

Participant demographic characteristics are detailed in Tables 1 and 2. The sample included teachers from all three regions as indicated in Table 1, however, the majority were from the Middle Governorates. Table 2 shows the detailed data of the participants' gender, educational level and teaching experience. Notably, 72.9% of the sample was female and 69.6% had a bachelor's (B.A.) degree. Furthermore, 63.7% of teachers had over 10 years of teaching experience, indicating the study involved both novice and experienced teachers.

Table 1. The main three Palestinian regions of the participants

Southern Governorates	**Middle Governorates**	**Northern Governorates**
Hebron and the surroundings	Jerusalem, Jericho, Ramallah, Al-Bireh	Jenin, Tubas, Nablus, Tulkarm, Salfit, Qalqilya

Table 2. Data of Teachers' Gender, Educational level and Seniority

Gender	**Frequency**	**Percent**
Male	65	27.1
Female	175	72.9

Total	240	100.0
Academic Degree		
B.A.	167	69.6
Teaching Diploma (B.Ed.)	14	5.8
M.A.	54	22.5
Ph.D.	5	2.1
Total	240	100.0
Teaching experience		
1 – 5 years	59	24.6
6 – 10 years	28	11.7
More than 10 years	153	63.7
Total	240	100.0

3.4. Instrumentation

3.4.1. Instrument design

The questionnaire used in the study was designed based on a thorough literature review to highlight teaching practices that support the development of MC. The strategies involved were primarily conceptual problem solving, use of a range of mathematical skills, class discussion, infusion of technology, guess work, mathematical reasoning, activities for divergent thinking, problem posing activities, use of mathematics in real life, imagination and connection to art or music. The questionnaire was carefully designed to maintain a strong focus on the key questions posed by the study, while also ensuring that the questions being answered were as clear and relevant as possible. To improve its reliability and validity, a pilot test was performed with a small group of teachers, and their feedback was used to revise the final version.

3.4.2. Validity and reliability

3.4.2.1. Validity

The validity of the questionnaire was established through a thorough process that included content validation and expert reviews. To identify the items representing the teaching practices that promote MC, the researchers conducted a comprehensive study of relevant literature. These items were

identified as: problem-solving, technology integration, guessing and trying, mathematical reasoning, divergent thinking, problem posing, real-life applications of mathematics, imagination, and connections to art and music. Accordingly, the 34-item questionnaire was developed.

To confirm the content validity, the developed questionnaire was reviewed by seven professors of mathematics education from local and regional universities, and they gave feedback. All reviewers agreed to use the questionnaire, though, they proposed minor amendments to enhance some of the questions' wording and structure. These changes made it into the final version of the questionnaire, ultimately confirming its alignment with the intended items. The questionnaire is available upon request.

3.4.2.2. Reliability

Reliability analysis was performed with a pilot sample of 30 participants, different from the main study sample of 240 teachers. Cronbach's Alpha was calculated to find whether the items in the questionnaire consistently measured the same underlying constructs. The Alpha value was .958 suggesting a very good internal consistency (Bujang, Omar, & Baharum, 2018). This reliability score is high, indicating that the questionnaire items are consistent and reliable to measure the constructs we need.

3.5. Data collection procedure

Data was collected over a predefined time. Participants were clearly instructed and assured that their answers were confidential when the online questionnaires were administered. The emails to teachers from public schools were sent through a list provided by the Palestinian Ministry of Education. For teachers of private and UNRWA schools, it was sent through email messages to all schools' principals, and in the case of UNRWA schools, an education officer in each governorate distributed the link to the questionnaire. Overall, 341 teachers were targeted, according to the study. A total of 240 teachers voluntarily filled out the questionnaire with a response rate of 70.4%, above the minimum recommended response rate of 70% (Al Khalaf et al., 2022).

3.6. Variables

3.6.1. Independent variables

The independent variables include the demographic characteristics of teachers, such as:

Gender: Categorized as Male or Female

Education: B.A., B.Ed., M.A., Ph.D..

Seniority: Defined by years of teaching experience: 1 – 5 years, 6 – 10 years, or more than 10 years.

These variables were selected based on their potential influence on teachers' pedagogical practices and their capacity to promote creativity in mathematics teaching.

3.6.2. Dependent variables

The dependent variables are the items of a questionnaire designed to assess nine teaching practices identified in the literature as fostering MC among students. These practices are:

1. Concept-Based Problem Solving
2. Utilizing Various Mathematical Skills
3. Class Discussion
4. Technology Integration
5. Guessing
6. Mathematical Reasoning
7. Divergent Thinking Exercises
8. Problem Posing
9. Real-Life Applications of Mathematics

3.7. Data analysis

Data analysis was conducted using SPSS 26. Descriptive statistics were computed to summarize the sample's demographic characteristics. The results are presented in the Results section. The data was found to fail the normality test, leading to the use of non-parametric tests (Field, 2017) such as Mann-Whitney U Test to compare differences between two independent groups (e.g., male vs. female teachers), Kruskal-Wallis Test to compare differences among three or more independent groups (e.g., teachers with different levels of seniority or educational qualifications), and Spearman's

Rank Correlation to examine relationships between ordinal or non-normally distributed variables. The significance level was set at $p < .05$ for all analyses. Effect sizes were also calculated to assess the practical significance of the findings. All the relevant statistical tests' tables are available upon request.

4. Results

4.1. Introduction

The results are presented in the order of the statistical tests to address the research questions. First, we report the assumption tests for normality and homogeneity of variance, followed by descriptive statistics and the results of hypothesis testing. The findings emphasize significant differences in teachers' adoption of teaching practices that encourage MC, based on demographic variables.

4.2. Results of the assumption tests

4.2.1. Normality test results

The normality of the teaching practice variables was evaluated using the Kolmogorov-Smirnov and Shapiro-Wilk tests, whose results indicated that all variables significantly deviated from normality ($p = .00$ for both tests), confirming that the data were not normally distributed.

4.2.2. Assessing homogeneity

The homogeneity of variance was assessed using the Brown-Forsythe test for each independent variable: gender, educational level, and seniority. For gender, there were significant differences in variance were found for the teaching practices of 'Problem Solving' and 'Problem Posing and Research' ($F(1, 238) = 5.222$, $p = .023$; $F(1, 238) = 4.432$, $p = .036$) indicating varied responses between male and female teachers, while no significant differences were observed for the other teaching practices. Similarly, for educational Level, significant differences in variance were observed for the teaching practices of 'Problem Solving', 'Applying Mathematics to Real-Life Problems', and 'Relating Mathematics to Art' ($F(3, 236) = 3.635$, $p = .014$; $F(3, 236) = 3.278$, $p = .022$; $F(3, 236) = 2.950$, $p = .033$), and no significant differences were found for the other practices. However, for seniority, no

significant differences in variance were found for any of the teaching practices, indicating that the teachers' experience did not affect the variability of their responses.

4.3. Descriptive statistics

4.3.1. Overview of teaching practices

An analysis of the identified teaching practices to foster MC showed variations in how frequently they were used. Teachers reported the highest levels of engagement in problem solving and mathematical reasoning, while practices such as using technology and divergent thinking were utilized less often. The average educational level of the participants was 1.57, which corresponds to B.A., with a standard deviation of 0.907.

4.3.2. Teaching practices by gender

Descriptive statistics were analyzed by gender to explore differences in teachers' involvement in various teaching practices. The results indicate that both male and female teachers exhibited high engagement in problem-solving, mathematical reasoning, applying mathematics to real-life problems, and guessing and trying. Male teachers demonstrated moderate to high engagement in practices such as divergent thinking, technology use, problem posing, research, imagination, and aesthetics in mathematics. Female teachers showed a similar pattern, with particularly strong engagement in problem solving, applying mathematics to real-life contexts, mathematical reasoning, divergent thinking, and imagination –exceeding male teachers by 7% in these areas. Overall, female teachers surpassed their male counterparts in adopting teaching practices that enhance MC, although both genders exhibited high engagement across most practices.

4.3.3. Teaching practices by educational level

Descriptive statistics were carried out according to teachers' educational levels (B.A., B.Ed., M.A., Ph. D.). The results showed that teachers with B.A. were extremely involved in problem solving, guessing and checking, mathematical reasoning, and using mathematics to address real-world issues, while moderately involved in using technology, divergent thinking, posing and researching problems, using imagination, connecting math to art. Similarly, teachers with B.Ed. showed high engagement into problem

solving, mathematical reasoning, diverse thinking, problem posing, and research, and moderate engagement into art and using technology. On the other hand, teachers with M.A. showed strong focus on problem solving, reasoning with mathematics, and quantitative applications, with moderate usage of technology, problem posing & research, and mathematics in relation to art. Finally, teachers with Ph.D. showed moderate engagement in problem solving, technology use, guessing and checking, mathematical reasoning, divergent thinking, applying mathematics to real-life problems, and imagination. However, they demonstrated low engagement in problem posing and integrating mathematics with art. Overall, B.Ed. teachers exhibited the most integrated use of teaching practices that promote MC, followed by Ph.D. holders, who showed variability in their engagement levels.

4.4. Addressing the research questions

4.4.1. Research Question 1: Does teachers' gender significantly influence their use of teaching practices that foster MC in eighth- and ninth-grade classrooms?

Table 3. Mann-Whitney Test Statistics between Male and Female Teachers

	Mann-Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. (2-tailed)**
ProblemSolving	3966.000	6111.000	-3.620	0.000
UsingTechnology	4133.000	6278.000	-3.276	0.001
GuessAndTrying	4239.500	6384.500	-3.066	0.002
MathReasoning	3978.500	6123.500	-3.605	0.000
DivergentThinking	4662.500	6807.500	-2.168	0.030
PrblmPosingResearch	4276.000	6421.000	-2.975	0.003
AppMathToRealLife	4136.000	6281.000	-3.293	0.001
UsingImagination	4196.500	6341.500	-3.157	0.002
RelatingToArt	3438.500	5583.500	-4.734	0.000

The Mann-Whitney U test, as a non-parametric test, was used to compare the responses of male and female teachers regarding their use of teaching practices that promote MC. The results show that female teachers had higher mean ranks and sums of ranks than male teachers in 100% of

teaching practices. In conclusion, the Mann-Whitney U test was statistically significant for all teaching practices between male and female teachers, $p < .005$.

4.4.2. Research Question 2: Does teachers' educational level significantly influence their use of teaching practices that foster MC?

A Kruskal-Wallis H test was run to identify statistically significant differences between four different groups of teachers depending on their educational levels (B.A., B.Ed., M.A., or Ph. D.). The results, presented in Table 4 reveal differences in mean ranks between the groups as follows: B.A. (118.49 – 126.51), B.Ed. (117.21 – 155.79), M.A. (101.86 – 128.74), and Ph.D. (27.80 – 99.3). Teachers with a teaching diploma (B.Ed.) had the highest mean ranks, while those with a Ph.D. had the lowest.

Table 4. Test Statistics for the Kruskal-Wallis H Test, with Respect to Educational Level

	Kruskal-Wallis H	**df**	**Asymp. Sig.**
ProblemSolving	10.765	3	0.013
UsingTechnology	1.314	3	0.726
GuessAndTrying	5.041	3	0.169
MathReasoning	4.915	3	0.178
DivergentThinking	5.545	3	0.136
PrblmPosingResearch	7.292	3	0.063
AppMathToRealLife	13.454	3	0.004
UsingImagination	5.438	3	0.142
RelatingToArt	10.180	3	0.017

The Kruskal-Wallis H test revealed significant differences in problem solving ($H = 10.765$, $p = .013$), applying mathematics to real-life ($H = 13.454$, $p = .004$), and relating mathematics to art ($H = 10.180$, $p = .017$). No significant differences were observed in the rest of the teaching practices ($p > .05$).

Post-Hoc Pairwise Comparisons Using Mann-Whitney U Tests with Bonferroni Correction

Post-hoc pairwise comparisons were conducted using the Mann-Whitney U test with a Bonferroni correction to identify specific differences among the groups. Six pairwise comparisons were made with the four groups, and the significance level was adjusted to p = .008 (i.e., .05 / 6). The results of the post-hoc analysis identified no significant differences in teaching practices in either the comparison between B.A. vs. B.Ed. or between B.A. vs. M.A. However, significant differences were found only in problem solving (U = 87.5, p = .003) for B.A. vs. Ph.D., Table 5. B.A. teachers having higher mean ranks than those with Ph.D. indicating more lavish use of problem-solving practices, and no significant differences were observed in the rest of the practices (p > .008).

Table 5. The Mann-Whitney U Test Comparison between B.A. and Ph.D. (Post-Hoc Comparison)

	Mann-Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. p**
ProblemSolving	87.500	102.500	-3.023	0.003
UsingTechnology	330.500	345.500	-0.799	0.424
GuessAndTrying	254.500	269.500	-1.503	0.133
MathReasoning	224.000	239.000	-1.777	0.076
DivergentThinking	207.000	222.000	-1.938	0.053
PrblmPosingResearch	182.000	197.000	-2.161	0.031
AppMathToRealLife	171.000	186.000	-2.286	0.022
UsingImagination	230.500	245.500	-1.724	0.085
RelatingToArt	206.500	221.500	-1.937	0.053

Key Findings

The Kruskal-Wallis H test followed by post-hoc pairwise comparisons showed a significant effect between teachers' education level and their teaching of practices promoting MC with special relevance in problem solving, using mathematics and relating mathematics to art. B.Ed. teachers were the most engaged with these practices, while those with a Ph.D. were the least.

These results highlight the need for further detailed research on how teacher qualifications can positively affect students' MC.

4.4.3. Research Question 3: Does teachers' seniority significantly influence their use of teaching practices that foster MC?

A Kruskal-Wallis H test was implemented to examine the teachers' responses stratified into three levels. The results are presented in Table 6, and the groups differ in mean ranks. Teachers of (1 – 5 yrs.) exhibited higher mean ranks in most teaching practices, while (6 – 10 years) teachers showed lower mean ranks than the other groups (92.16 – 124.16). Those with more than 10 years had higher mean ranks in most teaching practices.

Table 6. Test Statistics for the Kruskal-Wallis H Test, with Respect to Seniority

	Kruskal-Wallis H	**df**	**Asymp. Sig.**
ProblemSolving	3.823	2	0.148
UsingTechnology	7.953	2	0.019
GuessAndTrying	0.704	2	0.703
MathReasoning	1.132	2	0.568
DivergentThinking	2.364	2	0.307
PrblmPosingResearch	5.152	2	0.076
AppMathToRealLife	6.003	2	0.050
UsingImagination	9.627	2	0.008
RelatingToArt	5.576	2	0.062

Key Findings

Post-Hoc Pairwise Comparisons

Post-hoc pairwise comparisons were conducted using the Mann-Whitney U test with a Bonferroni correction to identify specific group differences. The three seniority groups were analyzed. This resulted in three pairwise comparisons, and the significance level was adjusted to $p = .017$ (i.e., .05 divided by 3). The analysis revealed that there were no significant differences found ($p > .017$) in teaching practices either between (1-5 yrs. vs. 6-10 yrs.) or between (1-5 yrs. vs. over 10 yrs.). Meanwhile, significant

differences were found between (6-10 yrs. vs. over 10 yrs.) in using technology, applying mathematics to real-life, and using imagination, as shown in Table 7.

Table 7. The Mann-Whitney U Test Comparison between (6 – 10) and (> 10) Seniority across all Teaching Practices

	Mann-Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. p**
ProblemSolving	1694.5	2100.5	-1.766	0.077
UsingTechnology	1540	1946	-2.38	0.017
GuessAndTrying	1942	2348	-0.794	0.427
MathReasoning	1880.5	2286.5	-1.034	0.301
DivergentThinking	2137	13918	-0.02	0.984
PrblmPosingResearch	1651	2057	-1.941	0.052
AppMathToRealLife	1540.5	1946.5	-2.395	0.017
UsingImagination	1479	1885	-2.631	0.009
RelatingToArt	1688	2094	-1.792	0.073

Key Findings

The results of the Kruskal-Wallis H test and the followed post-hoc pairwise comparisons show that teachers' experience significantly affect their implementation of teaching practices that foster MC, especially with using technology, applying mathematics to real-life problems and in using imagination. Teachers with more than 10 years of experience are more likely to integrate these practices than those with 6-10 years. However, there were no significant differences found between teachers with 1 to 5 years of experience and the other groups.

4.4.4. *Research Question 4*: Are there significant interaction effects between teachers' educational level and seniority on their use of teaching practices that foster MC?

This question was answered by using the Aligned Rank Transform (ART) procedure, then conducting a Multivariate Analysis of Variance (MANOVA) on the rank-transformed data. This method is relatively robust to violations of normality and homogeneity of variance and is appropriate

for exploring interaction effects in non-parametric datasets (Elkin et al., 2021; Leys & Schumann, 2010).

Testing Assumptions

The researchers checked the assumption of equal covariance matrices with Box's M test before implementing the MANOVA. As shown in Table 8 the covariance matrices differ significantly between groups (Box's M = 477.45, F = 1.31, p <. 01), indicating that the assumption has been violated. However, the ART procedure can be performed, and a valid analysis can still be obtained, even when assumptions are violated.

Table 8. The Box's Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.
477.454	1.314	275	8193.22	0

The MANOVA results in Table 9 assessed the main effects of teachers' educational level and seniority, including their interaction effects. Their analysis indicate that there were no significant main effects observed for teachers' educational level (Pillai's Trace = 0.091, F = 0.696, p = .888) or seniority (Pillai's Trace = 0.102, F = 1.185, p = .263). Additionally, there was no significant interaction between educational level and seniority (Pillai's Trace = 0.258, F = 1.216, p = .147). However, Roy's Largest Root test suggests a potential interaction effect on one or more dependent variables (Roy's Largest Root = 0.114, F = 2.547, p < .01).

Univariate ANOVA and Post-Hoc Analysis

Univariate ANOVA was conducted on the rank-transformed data to investigate the potential interaction effect. The results indicate that there were no significant differences or interaction effects for most teaching practices (p > .05). Nevertheless, a slight interaction effect was observed for the category "Applying Mathematics to Real-Life Problems" (p = .061). Post-hoc tests using Tukey's HSD were also performed to examine group differences related to education and seniority factors, whose results indicate no significant differences among the various educational or seniority levels (p > .05).

Table 9. Multivariate Tests

Effect		Value	F	Hypthsis df	Error df	Sig.	Partial η^2
Intercept	**Pillai's Trace**	.463	18.937	10.00	220.00	.000	.463
	Wilks' Lambda	.537	18.937	10.00	220.00	.000	.463
	Hotelling's Trace	.861	18.937	10.00	220.00	.000	.463
	Roy's Largest Root	.861	18.937	10.00	220.00	.000	.463
Education	**Pillai's Trace**	.091	.696	30.00	666.00	.888	.030
	Wilks' Lambda	.911	.694	30.00	646.42	.890	.031
	Hotelling's Trace	.095	.693	30.00	656.00	.891	.031
	Roy's Largest Root	.058	1.282	10.00	222.00	.242	.055
Seniority	**Pillai's Trace**	.102	1.185	20.00	442.00	.263	.051
	Wilks' Lambda	.901	1.182	20.00	440.00	.265	.051
	Hotelling's Trace	.108	1.180	20.00	438.00	.267	.051
	Roy's Largest Root	.072	1.584	10.00	221.00	.113	.067
Education * Seniority	**Pillai's Trace**	.258	1.216	50.00	1120.00	.147	.052
	Wilks' Lambda	.765	1.217	50.00	1006.72	.147	.052
	Hotelling's Trace	.278	1.216	50.00	1092.00	.148	.053
	Roy's Largest Root	.114	2.547	10.00	224.00	.006	.102

Key Findings

The analysis indicated that there are no significant effects on the use of teaching practices stimulating MC based on teachers' educational level or seniority. The findings show that there is minimal effect of the interaction

between teachers' level of education and experience on their use of creative teaching practices.

4.5. Summary of results

The main results of the study are:

Gender Differences: Compared to their male counterparts, female teachers were significantly more engaged in all teaching practices, indicating that gender has a substantial impact on which ways teachers use to encourage MC.

Educational Level: B.Ed. teachers demonstrated the highest level of engagement in creative teaching practices, while Ph.D. holders showed the lowest. Additionally, B.A. teachers outperformed Ph.D. holders in problem solving.

Seniority: Teachers with seniority higher than 10 years scored considerably higher in technology use, applicability of mathematics to real-life situations, and using imagination than those with 6 – 10 years of experience. Teachers with 1 – 5 years' experience did not differ from the other groups on any significant measures. No significant interaction effects of teachers' educational level or seniority were observed.

One part of findings is that teachers' gender and seniority influence practices which develop MC, while education level and its interaction with seniority has no meaningful impact on them.

5. Discussion

Gender Differences in Teaching Practices

Female teachers demonstrated higher levels of integrating teaching practices that foster MC than their male counterparts. The results of the Mann-Whitney U Test positively confirm the answer for the first research. This finding aligns with previous studies indicating a higher level of involvement and adoption of creativity-fostering teaching practices (Alqaisi, 2010; Diwa et al., 2023; Zibenberg & Da'as, 2022).

Influence of teachers' educational levels on their teaching practices

The results of the study via the Kruskal-Wallis H Test indicated significant differences among teachers with varying educational levels,

positively confirming the answer for the second research question. These findings suggest that B.A. teachers may have more recent training in teaching methods, while M.A. teachers possess more profound content knowledge, enabling them to implement reasoning more effectively. Furthermore, Ph.D. teachers might focus more on research rather than practical teaching strategies (Chen, 2014). Not only do the findings align with studies suggesting that educational background influences teachers' approaches to fostering creativity (Odena & Welch, 2012; Hong et al., 2009; Ayele, 2016), but they also reveal specific teaching practices that each group (B.A. teachers vs. M.A. teachers) integrates into their instructions. This provides precise practical suggestions regarding the needs of each group to be addressed in PD courses aimed at fostering MC.

Influence of teachers' seniority levels on their teaching practices

The findings indicated a significant difference in responses as teachers' years of seniority increased. The results of the Kruskal-Wallis H Test revealed significant differences based on seniority, positively confirming the answer for the third research question. The underlying reason for these findings can be the content knowledge, teaching strategies, and classroom management skills of the teachers that are acquired over years of practicing teaching. With this, they can also face class challenges easily, break down complex concepts and allow for MC. Thus, having experienced teachers guide new teachers through PD courses as instructors and trainers is recommended.

Interaction effect between teachers' educational levels and their teaching experience

The results of the Multivariate Analysis of Variance (MANOVA) showed that there is no significant overall interaction between teachers' educational levels and their seniority regarding their implementation of teaching practices that foster MC, negatively addressing the fourth research question.

6. Conclusions

The study provides deep insights into the impact of teachers' demographic characteristics on the implementation of teaching practices that promote MC among eighth- and ninth-grade students in Palestinian

classrooms. These results show significant differences in responses regarding teachers' demographics, which offer fine-grained insight into how these factors influence teachers' adoption of innovative practices that promote MC in the classroom.

First, the study reveals that female teachers were more likely than male teachers to integrate practices that promote MC. This resonates with current literature and highlights the need for gender-sensitive PD programs that enable all teachers to use creative pedagogies.

Second, teachers' educational level was shown to be associated with unique teaching practices. Eligible B.Ed. teachers showed the most engagement in teaching practices focused on creativity. On the other hand, B.A. teachers emphasized technology integration, divergent thinking and relating mathematics to art. Meanwhile, M.A. teachers focused on mathematical reasoning and open-ended problem-solving. Ph.D. holders engaged in these practices than those with a lower level of higher education, which may reflect their greater involvement in research than classroom instruction. These results indicate that teacher preparation programs should be customized to address the needs and strengths of educators according to their qualifications.

The third finding is that teachers with more experience intend to adopt other teaching practices in their teaching (such as using technology, applying math to real-life). This highlights the benefits of involving experienced teachers as mentors or facilitators in PD activities or workshops to help newer colleagues foster creativity.

In conclusion, the study reported a non-significant interaction between teaching experience and educational qualifications of teachers, implying that these factors independently affect teaching practices. This implies that there are other factors that may have more influence on teaching practices such as the school environment, access to resources and teaching aids or intrinsic motivation.

This study adds to the research on MC and PD for teachers by highlighting the demographic factors that influence how they teach. This research offers practical insights into how to create targeted training programs that account for teachers' differing needs shaped by gender,

educational level, and experience. Additionally, the research highlights how mathematics education should encourage creativity to help students face the challenges of the 21st century. Future studies should consider other contextual variables underlying teachers' practices and examine the long-term effect of creativity-based pedagogies on student learning outcomes.

7. The study limitations

Although this study provides rich insights into the factors that influence teachers to adopt creativity-focused teaching practices, certain limitations need to be highlighted.

Dependency on Self-Reported Data: The main method of data collection was a questionnaire, which depended on self-reported answers. However, this methodology may be susceptible to response bias – particularly social desirability bias – where participants provide answers they believe are favorable or socially acceptable, rather than accurately reflecting their actual practices.

Absence of Observations: The study relied solely on self-reported practices without observing teachers implementing creativity-focused strategies in their classrooms or conducting interviews. Observation could unveil differences between reported practices and real behaviors in the classroom.

Context-dependence of Results: The study is set in the Palestinian context, and as such, its findings may not be generalizable beyond educational settings that present similar cultural, institutional, or resource-related dynamics.

The study was limited to specific demographic factors of the participants. Other potentially influential factors were not examined, like school culture, access to resources or teachers' intrinsic motivation.

8. Implications and recommendations

Practical implications

This research could be of interest to teachers, school administrators and policymakers who seek to promote a creative environment for the mathematics class. Based on the findings, here are some tactical suggestions.

For teachers

– In their lesson plans, teachers are advised to incorporate open-ended problem-solving, divergent thinking, and real-life applications that allow room for creativity.

– They should always explore fresh pedagogical approaches and work with other teachers to exchange and polish innovative practices.

For school principals

– Create a school culture around collaboration by fostering team-based lesson development and peer observations.

– Facilitate consistent workshops and professional learning opportunities for creativity-driven teaching.

– Involve the more experienced teachers, as mentors for less-experienced colleagues via teaching workshops.

For policymakers

– Develop content-based PD programs that meet teachers' qualification/experience level needs.

– Ensure that PD programs are long-term and everlasting rather than one-off programs, staying with teachers throughout their career.

– Use veteran teachers as trainers for PD programs, offering real strategies that work in the classroom.

Suggestions for future research

Future research may build on the findings of this study and address its limitations by:

– Investigate Additional Influences: Look beyond individual or professional identity to a wider range of possible predictors of teachers' practices, such as school culture, resource access, and intrinsic motivation.

– Engage in Comparative Studies: Repeat similar studies covering various regional and international contexts to determine practical factors across a wide range of education systems.

– Use Mixed-Methods Approaches: Mixed-method designs that triangulate Likert-based questionnaires with classroom observations and teacher interviews are essential for exploring how teachers claim to engage in creativity-focused practices.

– Explore Long Term Effects: Research the longitudinal impacts of creativity-based pedagogical approaches on students' problem-solving abilities, engagement, and critical thought in mathematics.

9. Contribution to literature

The significance of this study lies not only in its approach and analysis, but also statistical evidence of how demographic factors influence teachers' practices aiming to foster MC. It also sheds light on how these factors affect the integration of particular teaching practices.

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